A Christmas gift good for a lifetime—a year's subscription to SCHOOL SCIENCE AND MATHEMATICS.

CONTENTS FOR DECEMBER, 1945

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS OFFICERS
1944–1945

President, Walter H. Carnahan, Purdue University, Lafayette, Indiana.
Vice-President, Joseph E. Dickman, Board of Education, Chicago, Illinois.
Secretary, Harold H. Metcalf, Oak Park, River Forest Township High School, Oak Park, Illinois.
Treasurer, Ray C. Soliday, P. O. Box 408, Oak Park, Illinois.
Historian, Edwin W. Schreiber, State Teachers College, Macomb, Illinois

BOARD OF DIRECTORS

Emil L. Massey
Board of Education
Detroit, Mich.
Geraldine Reep Johnson
Washington High School
Indianapolis, Ind.
John Mayfield
University High School, Chicago
J. T. Johnson
Chicago Teachers College
Chicago, Ill.
R. E. Park
Oak Park-River Forest Twp. H.S.
Oak Park, Ill.
Arthur O. Baker
Board of Education, Cleveland
George E. Hawkins
Lyons Twp. H.S. & Jr. C.
LaGrange, Ill.
Ruth W. Mikesell
De Paul University, Chicago
Paul L. Trump
University of Wis., Madison
Charlotte L. Grant
Oak Park-River Forest Twp. H.S.
Oak Park, Ill.
Fred D. Leonhard
Mackenzie H.S., Detroit
Mary A. Potter
Board of Education
Racine, Wis.
J. E. Potzger
Butler University, Indianapolis

SECTION OFFICERS

Biology

Ch.—Ross Aeby
Oak Park-River Forest Twp. H.S.
Oak Park, Ill.
V. Ch.—Ethel Schierbaum
Harper H.S., Chicago, Ill.
Sec.—Fred J. Burdine
Thornton Twp. H.S.
Harvey, Ill.

Chemistry

Ch.—Fred W. Moore
High School, Owosso, Mich.
V. Ch.—Walter Geisler
Shortridge H.S., Indianapolis
Sec.—Loren T. Lucas
Lake View H.S., Chicago

Elementary Mathematics

Ch.—Violet Weisen
Irving Park El. School, Chicago
V. Ch.—Ross Herr
Princ. Trumbull School, Chicago
Sec.—Albert H. Goodrich
Irving Park El. School, Chicago

Elementary Science

Ch.—Clara Steyaert
Jefferson Sch., Davenport, Iowa
V. Ch.—Hildegard C. Pieper
Harte School, Chicago, Ill.
Sec.—Illa Pedendorf
Laboratory School, Univ. of Chicago

General Science

Ch.—A. W. Henderson
High School, Wood River, Ill.
V. Ch.—W. A. Porter
University High School
Madison, Wis.
Sec.—Harold Harris
Harper High School, Chicago

Geography

Ch.—Villa B. Smith
John Hay H.S.
Cleveland, Ohio
V. Ch.—Wm. Gregory
Western Reserve University
Cleveland, Ohio
Sec.—Lucille Kenney
Director of Visual Aids
Lakewood, Ohio

Mathematics

Ch.—Mildred Taylor
Fenger H.S., Chicago
V. Ch.—J. M. Kinney
Wilson Jr. College
Chicago, Ill.
Sec.—Vernon H. Price
University H.S.
Iowa City, Iowa

Physics

Ch.—W. N. Smith
East Technical H.S.
Cleveland, Ohio
V. Ch.—E. G. Plasterer
High School, Huntington, Ind.
Sec.—Antone Geisert
Von Steuben H. S., Chicago

SCHOOL SCIENCE AND MATHEMATICS

VOL. XLV DECEMBER, 1945 WHOLE NO. 398

"MATHEMATICIANS HAVE AGREED . . ."

CHARLES SALKIND
Samuel J. Tilden High School, Tilden Avenue and East 57th Street, Brooklyn, N. Y.

In an elementary algebra textbook recently off the press, we find the following:

> **Order of operations.** One of the "catch" questions in arithmetics was: Does $24 \div 3 \times 2$ equal 16 or 4?
>
> The meaning can be made clear by putting parentheses around the work that should be done first. Thus: $(24 \div 3) \times 2 = 16$ $24 \div (3 \times 2) = 4$
>
> If parentheses are not used the rule is: ***Working from left to right, do the multiplications first, wherever found:*** then do the divisions: and, last of all, do the additions and subtractions.

There is definitely no difference of opinion about the hierarchy of operations: first, involution and evolution, then, multiplication and division, finally, addition and subtraction. But some of us were reared on textbooks which taught that, when the choice is between multiplication and division only, if parenthesis are not used, the rule is: Working from left to right, *do the operations in the order in which they appear.*

An investigation of sixteen commonly used algebra texts revealed a disconcerting lack of agreement about the priority rating of these operations. Nine of the sixteen adopt the convention that multiplications and divisions are to be performed in the order in which they occur. Of these nine eight are explicit in their statement: the ninth implies this rule in giving the answer 100 to the example $40 \div 2 \cdot 5$. Four of the sixteen give the rule quoted at the beginning of this article. In two of these four we find the statement, "Mathematicians have agreed upon the following order," followed by the rule:

1. First perform all multiplications.
2. Next perform all divisions from left to right.

If this constitutes agreement, we shall have to find a new definition for the word.

We may conclude that, for want of a uniform convention about the order of operations with respect to divisions and multiplications, the only safe procedure is to use parentheses, or brackets and such.

How important is this question? Occasionally, pupils are in a position to make comparisons between textbooks. They are inclined to inflate a disagreement of this type beyond its importance. It would be desirable to have a single convention, but the question is not too important.

Authors, titles and page references will be supplied upon request.

A NEW CIRCUIT FOR FREQUENCY MODULATION

A new radio circuit for frequency modulation (FM) receivers which makes it possible for the first time to build a receiver that realizes the advantages of FM at a cost comparable to that of standard band receivers, was described October 3 by Stuart Wm. Seeley, manager of the Industry Service Division of RCA Laboratories, in a paper delivered to the New York Section of the Institute of Radio Engineers.

FM sets produced before the war, Mr. Seeley pointed out, required the use of one or more tubes whose functions were solely that of noise suppression. They contributed nothing to the volume of the receiver output. Furthermore, he said, to make these extra tubes fully effective, considerable amplification of the received signal was necessary. Although both of these requirements added noticeably to the cost of FM receivers, noise continued to be present when the strength of a received signal fell below a certain point called the threshold level.

According to Mr. Seeley, the new RCA circuit, called a ratio detector, is insensitive to electrical interference of all kinds, whether man-made by ignition systems, oil burners and domestic appliances, or natural, such as atmospheric static.

Mr. Seeley added that the new circuit is not only free of a critical threshold signal level, operating equally effectively on strong and weak stations, but its incorporation in a receiver eliminates the need for additional tubes and parts that formerly were considered necessary in frequency modulation receivers. It is this simplification, he said, that should reduce the manufacturing cost of FM receivers to a point comparable with that of receivers covering the standard broadcast bands.

The national security of the United States demands that military scientists and industrial scientists continue their cooperation; for peace and security rise and fall with science.

DAVID SARNOFF

CONICS ARE FUN

Norma Sleight
New Trier Township High School, Winnetka, Illinois

One of the greatest advantages resulting from ability grouping is the improvement in method and material the teacher can produce if the reactions of a high ranking class are watched and noted carefully. The student of exceptional ability is very frank. He is talkative, not averse to stating that certain topics are dull, and can ask more good questions in five minutes than can be answered convincingly in a week. If twenty-five of this type of student are gathered together, the teacher becomes merely a referee at times, and the interplay among members of such a class just carries a topic along quite naturally and logically.

The writer of this report has found that the high school intermediate algebra class takes unusual pleasure in the study of the second degree equation in two unknowns. The following was assigned to an accelerated algebra class a short while ago as a joke:

"Plot the following carefully on the same axes. The arithmetic involved will be simple if you do not attempt to expand and clear the equations of fractions.

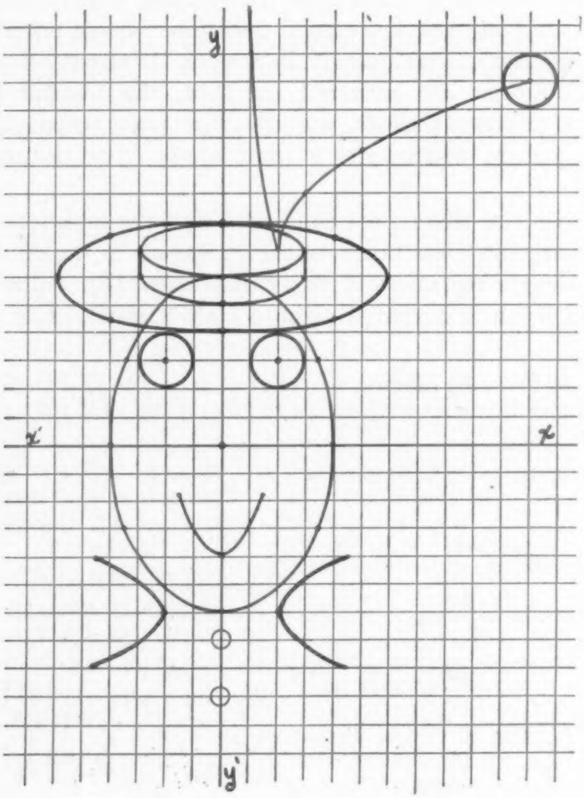
1. Place points $(\pm 2, 3)$ on the graph.
2. Plot $\frac{x^2}{16}+\frac{y^2}{36}=1$
3. Plot $\frac{x^2}{36}+\frac{(y-6)^2}{4}=1$
4. Plot $\frac{x^2}{9}+\frac{(y-6)^2}{1}=1$ and omit numbers greater than $y=6$.
5. Plot $\frac{x^2}{9}+\frac{(y-7)^2}{1}=1$
6. Join with a straight line extreme left points of numbers 4 and 5 above. Do same for right points.
7. Plot $(y-7)^2=4(x-3)+4$. Use values from $y=7$ through 13.
8. Plot $xy=14$. Use values from $y=7$ through 17.
9. Plot $(x-11)^2+(y-13)^2=1$
10. Plot $(x-2)^2+(y-3)^2=1$
11. Plot $(x+2)^2+(y-3)^2=1$
12. Plot $x^2+4y^2=0$
13. Plot $x^2=(y+1)+3$. Use values from $x=-1.5$ to 1.5.
14. Plot $\frac{x^2}{4}-\frac{(y+6)^2}{1}=1$ from $y=-4$ to -8.
15. Plot $x^2+(y+7)^2=\frac{1}{16}$
16. Plot $x^2+(y+9)^2=\frac{1}{16}$ etc.

When you have finished, if you are not too exhausted, say HELLO."

About half the class carried this assignment to completion. See the diagram for the solution.

How did this assignment happen to be made? Various mem-

bers of the class for some time had been decorating their graphs of conics "artistically," a custom which grew to great proportions. Since the graph work was invariably correct, one could not object to the superfluous decorations, but it was decided that if they wished to draw pictures, they could, but would learn some mathematics during the process. Well, the joke was on the teacher because they learned more than was intended. This will be explained later.



Since the list of equations to be graphed looks a little difficult, it may be well to give the background leading up to this special assignment.

When studying loci during the sophomore year, many of these high ranking juniors had constructed conics, including such problems as (1) to construct the locus of a point equidistant from a given fixed line and a given fixed point, (2) to con-

struct the locus of a point such that the sum of the distances from two fixed points is constant, and (3) to construct the locus of a point such that the difference between the distances from two fixed points is constant. A few had constructed the conics on the basis of eccentricity; that is, to construct the locus of a point such that the ratio of the distances from a given fixed point to a given fixed line is constant, say 1 to 1, 1 to 3, and 3 to 1. Thus they came to their junior year with some appreciation for the geometric aspect of conics.

Many junior algebra books start the subject of the second degree equation in two unknowns with a list of nice neat central conics to be graphed singly then in pairs for common points. Following soon thereafter students are subjected to a list of simultaneous equations to be solved algebraically. Many of these contain terms which translate (x or y terms) or rotate (xy term) the axes, or perhaps both. Not once has the writer covered this important topic with a superior class without a bombardment of questions. After having learned to recognize the simple conics from their equations, it is very natural to ask what type curve can be expected from these more general equations of the conics.

If the superior students are instructed carefully to make full use of intercepts, positive and negative values, to solve for x in terms of y and y in terms of x, then to have handy a square root table, they can manage to graph any of these second degree equations.

A list such as

$$4x^2+y^2+2y=15 \tag{1}$$

$$4x^2+y^2-2y=15 \tag{2}$$

$$4x^2+24x+y^2=-20 \tag{3}$$

$$4x^2-24x+y^2=-20 \tag{4}$$

$$x^2-2x+y^2+6y=6 \tag{5}$$

will answer the question regarding the effect of the presence of the first degree terms in x and (or) y. Since the list is long and there is much duplication the equations can be distributed among various members of the class. When the graphs are brought together later, results can be compared.

The set

$$xy+2y=16 \tag{6}$$

$$xy-2y=16 \tag{7}$$

$$xy-y^2=4 \tag{8}$$

$$xy+y^2=4 \tag{9}$$

can be handled in a similar fashion. Do all equations containing the xy term produce hyperbolas? Of course, if either of the square terms is missing, this is true. Take as the next set for outside work,

$$x^2+xy+y^2=4 \tag{10}$$

$$x^2+3xy+y^2=4 \tag{11}$$

and the group can answer its own question.

Invariably some efficiency expert will demand to know why one can't determine whether these equations will give an ellipse, parabola, or hyperbola without the arduous process of graphing. While a logical explanation is out of place at this level, the students can be given the facts. In the general equation of the second degree in two unknowns, $Ax^2+Bxy+Cy^2+Dx+Ey+F=0$, if B^2-4AC is greater than 1, we have a hyperbola. If $B^2-4AC=1$, we have a parabola. If B^2-4AC is less than 1, an ellipse is the result. These statements, checked back with various graphs and their equations, have a soothing effect upon members of the class.

Coming back to the specific class and the special assignment given them, what looked like an arduous task was finished in record time. Why? Apparently there was sufficient duplication in the list of equations to enable the students to sense the significance of the standard forms of both the circle and the ellipse. They had had the equation of the straight line in intercept form,

$$\frac{x}{a}+\frac{y}{b}=1,$$

earlier in the semester, therefore had some appreciation of the meaning of standard form. Without any specific teaching, all the students who finished graphing the picture were able to *sketch* a circle from its equation written in standard form, $(x-h)^2+(y-k)^2=r^2$, and conversely, given the center and radius could write the equation of the circle. The connection was made between the equation of the ellipse and its center and its semi-major and semi-minor axes in the same fashion,

$$\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1.$$

The hyperbola was more difficult. The center of this equation was simple and since the axis is horizontal, the vertices are found by using the ordinate of the center. While much of the rest of the picture was sketched, this hyperbola had to be plotted point by point. A few days earlier, the asymptotes of the equation

$$\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$$

were studied, that is

$$\frac{x}{a}\pm\frac{y}{b}=0.$$

When the general equation

$$\frac{(x-h)^2}{a^2}-\frac{(y-k)^2}{b^2}=1$$

was presented, one boy in true Sherlock Holmes fashion, said, "I suspect that the equations of the asymptotes are

$$\frac{x-h}{a}\pm\frac{y-k}{b}=0$$

then their slopes would be $\pm b/a$ so, with the center known, can't the asymptotes be drawn?"

Some effort was spent in writing the equations of circles, hyperbolas, and ellipses in standard form, then sketching. After having plotted similar equations the hard way, appreciation for the shorter method ran high. The parabola excited very little comment. Perhaps this is because the parabola is lacking in point symmetry.

In conclusion, an assignment intended to entertain the class, surprised the originator by automatically teaching the standard forms of the circle and ellipse. Can't someone clarify the standard forms of the hyperbola and parabola in like fashion?

SANDPAPER COATED ELECTRICALLY

Sandpaper is coated by artificial lightning! Instead of just dropping abrasive grains on animal glue coated backings, one well known manufacturer uses electric charges to stand the abrasive grains on end, and to space them regularly. This process stems from the fact that the most efficient grains are twice as long as they are wide.

INTRODUCTION TO "LIFT"

HAROLD Z. HARRIS
Harper High School, Chicago 36, Illinois

"Yes, Pa, that's a P-51 up there. Notice the wing shape. In school the last few days we've been talking about why its wings will lift an airplane.

"I remember that the teacher had handy a piece of a model airplane wing. It was made of tissue paper and wood, and he had used sticky paper to attach its trailing edge to a cigar box. He called for a volunteer with strong breath. We decided Johnny Allen was the boy for the job. Johnny laughed and went up there, and blew across the wing's top—and that wing flew up except where it was fastened.

"It was fair, too; none of his breath could have got underneath. Well, then we all asked 'how come,' and the teacher in turn wanted to know if we were willing to go through some stuff, step by step, to see why the wing went up. We agreed. Then we started.

"Jimmy, that kid who scares so easily, was asked by the teacher to fill a tumbler with water and place a piece of paper on top. Then the teacher said, 'James, turn the glass over—go on, hold it upside down.' And you know, while we got ready to laugh, Jimmy turned the glass over—and nothing happened. The paper stayed in place.

"He held it sideways, too, and at other angles, and still that paper held the water. Then Jimmy was told to pour out the water, put a dry sheet of paper on the glass—and repeat. This time he was'nt so slow about turning the tumbler over; but this time the paper did fall off.

"We all talked back and forth about the experiment, and finally we came to an agreement. You see, Pa, air is divided in little pieces like shrapnel; these fragments move fast, there's a lot of them, and they fly in all directions. They're called molecules.

"At first, when Jimmy filled the glass with water he didn't leave any room in it for air. There was plenty of air outside the glass, though. When he turned the tumbler over, the air smacking from below held the paper tight against the tumbler's rim; it was stronger than the weight of the water and the paper. But the piece of paper wouldn't stay on the rim of the inverted tum-

bler after it was emptied, because this time there was air inside the glass too.

"This wasn't as much of a surprise as you might think, Pa. We started to remember some stuff we'd done smashing oil cans by driving the air out of them; trying to pour grapefruit juice out of a can having only one hole punched in it; and so on; and Jenny Brown brought up the subject of tornadoes.

"Then the teacher said we could do the same thing with liquids. On the table he had an empty tin can. He had punched holes into the sides and the bottom of the can, and covered these openings with paper tape. The original lid of the can was near by; it had holes in too, but they weren't covered. After he filled the can with water, he had two fellows pull off the tape while he pushed down on the lid. Water spurted out of the bottom, of course, but also out of the sides, and out of the holes and around the edges of the lid. It seems that water, as well as air, presses in all directions.

"The teacher suggested we write down, so we could make an outline later, that: 1. *Fluids press equally in all directions.* Fluids are both gases and liquids. The teacher said we really hadn't shown the 'equally' part, but we were satisfied.

"Then we were shown a homemade atomizer. It was easy to make. Two lengths of glass tubing, each about a foot long, were stuck through holes in a big cork. They were at right angles. A corner of the cork, about a quarter of it, had been cut away so that the tubes came together in the open. I went up and worked it, so that part of one of the tubes was in a glass half full of colored water, while I blew through the other. Just my luck though —nothing happened.

"Then the teacher moved the tubes about a bit, so they came together a little more the way he wanted them to. I blew again through the horizontal tube, and this time the red water rose in the vertical tube until it was higher than the rest of the water in the tumbler. When I blew easily, the water came up just a little. When I blew hard, it came up a lot. When I blew real hard, the water came up and out of the vertical tube, and my breath broke it into a spray. I could have aimed this spray at any one in the front of the room.

"By then I was getting tired from the blowing, so it was easy for me to agree with the teacher when he said a spray gun was often better than an atomizer. You know, Pa, in a spray gun the

handle pushes the air forward so you don't have to blow. We didn't jot anything down, but sat back to see if we could follow the teacher while he tried to explain why atomizers worked.

"He started out by bringing out another glass; and he filled it partly with water. With his left hand he held a glass tube erect in it; with his right hand he pushed down on the water surface around the narrow tube. Of course, inside the tube the water rose. Then as he took away his wet fingers, he asked, 'What's pushing on the surface of the water, day and night?' That was easy; we knew it was air.

" 'Why doesn't the water rise in the tube now?' he wanted to know. Well, that was easy, too; there's also air in the tube. Then he got us to admit that if in some way the air pressure in the tube could be made less than the air pressure—the usual air pressure—which was pushing on the rest of the water surface, the water would rise in the tube. So that we could follow him, he made a sketch on the blackboard of the apparatus I had used in the atomizer experiment.

"Just above the opening of the vertical tube he drew a lot of arrows of equal length, all coming from the same point. They were to show molecules of air or water, pressing and squirting in all directions. While he was doing that, he had Helen Andrews read aloud the note we had written before: 'Fluids press equally in all directions,' so that we would get the idea of the arrows. Then he said slowly, 'Energy cannot be,' and stopped. We finished for him, like we always like to, 'be created or destroyed.' Then he lengthened one of the arrows, a horizontal one, the one pointing away from the horizontal tube. That arrow stood for a rush of air moving in one definite direction; I had been responsible for that movement of air because I had blown through the horizontal tube.

" 'What must I do with the rest of the arrows now?' the teacher asked. Most of us saw the point; if one of the arrows had been lengthened, the others must be reduced—according to the 'energy' law. So after repeating the statement of this law, we told him to shorten all the rest of the arrows. That included the one going down into the vertical tube. The teacher kept hammering at the point he was making: the arrow moving down into the vertical tube was a short one; it stood for less than usual air pressure.

"Most of us got the point. Although the air pressure in the vertical tube was less than usual, the air pressure on the surface

of the water in the rest of the tumbler had the regular value. Therefore, the water would rise in that tube, because the pressure on it everywhere outside of the tube was greater.

"We knew it was about time to put down another note. The one we wrote was: 2. *When the velocity of a fluid increases, the sideway pressure of that fluid decreases.* So far we were O. K.; and then the bell rang. But we knew we'd go on the next day.

"The next day we did go on to the next step in our discussion of why a wing rises. The teacher had attached a long piece of rubber tubing to a water faucet. I guess there was a fair amount of pressure, because the water jumped about three feet beyond the opening when he held the tube flat. But when he blocked most of the tube opening with his thumb, the water almost reached Henry Lane who sits up front, and Henry was a full ten feet away. And the water flew so fast, Henry wouldn't have had a chance to duck. You know, Pa, how you used to shower me when you'd put your thumb over the hose nozzle—you know how strong and fast the stream would be.

"Then, by means of some blackboard drawings, we figured a fluid should speed up when it went through a kink in the hose, also. The teacher tried to show us it was actually so. He had a three foot section of glass tubing that was a half inch thick most of its length. But earlier he had heated and then pulled out the center part, so that section was only a quarter inch wide. He slipped one end into the rubber tubing attached to the faucet, and made a little hole in the rubber just before it joined the glass. When he turned on the water, air went into the hole because the fast moving water had very little sideway pressure; and a mixture of water and air bubbles ran through the glass tube. And Pa, you could see the bubbles become tightly packed and pick up speed when they went through the narrow place. You see, the smaller space jammed the particles of the fluid, so each particle had to move faster.

"And so we wrote a third note: 3. *A fluid increases its velocity when a narrowing of its path causes crowding.* You know the same thing happens in rivers. The next experiment we did seemed unconnected with the other ones, at the time.

"Dave Clark was asked to put his lips close to the back of a blackboard eraser, and hold a lighted match at its front. Then he was told to blow hard enough to put out the light. He blew and he blew, but he couldn't blow it out. Do you see why, Pa? His breath would hit the back of the eraser, move to either side,

and then the straight edges of the eraser would keep the wind going forward. No moving air would touch the flame.

"Dave tried the same thing again, but this time used a tumbler instead of the eraser. This time the match went out. The moving air must have hugged the drinking glass all the way around. If we had had a tear drop or pear shaped object, instead of a round glass, the match would have been blown out even more easily.

"Therefore, we wrote down as a fourth note: 4. *Moving fluids follow a surface, if the surface changes direction smoothly and slowly.* As we looked up, we wondered what the teacher was going to do with the knife he held.

"We hadn't waited long before he displayed a cheap glider model wing; and he cut that wing, leading edge to trailing edge. He held up the cut section so we could see what a cross section was. Then on the blackboard he drew a cross section of the wing. It was a very big sketch; flat at the bottom, the rest a typical wing curve, and the whole about two feet high at its topmost bulge.

"Starting about a foot to the left of the drawing, he put down about fifteen dots, one above the other and around three inches apart. The lowest dot was, I'd say, four inches lower than the flat base of the wing. He asked us to assume that these dots were the center points in horizontal layers of air which were approaching the wing. Starting with the bottom dot, he drew a straight line across the board, and of course it passed four inches under the wing all the way. The line he drew through the second dot was parallel to the first line, and was an inch beneath the wing bottom all along its length. The line he drew through the third dot went evenly forward until it almost hit the curved leading edge of the wing section.

"Then he paused, and had Jenny Prescott read note four. the one about air following a smooth curve. We took the hint, and chanted to him to hug the upper outline of the wing as he continued the line. When the line reached the back of the wing, he resumed drawing it horizontally, and at the same height as the dot he started it from. He did about the same, starting from the next eight dots. These lines started and ended three inches apart, but they were very close together at the top of the bulge of the wing. From the rest of the dots he drew only level parallel lines, as these dots were higher than any part of the wing.

"Then, pointing to the tightly packed lines, standing for

crowded layers of air moving to the right, where they went above the bulge of the wing, he asked Bob Klopp to read note three. That's the one which says a fluid increases its velocity when a narrowing of its path causes crowding. So we could see that the air would pick up speed above the bulge. Then the teacher pointed to the horizontal lines below the wing, which were three inches apart along their entire length, and asked, 'Will the air pick up speed here?' Well, since the lines weren't crowded together, we could see the answer was 'no.'

"Bob then read note two which says that when the velocity of a fluid increases, its sideway pressure decreases. Well, Pa, it dawned on us. Above the wing the air was increasing its speed, so its pressure downward—the part of its sideway pressure we were interested in—was decreasing. The air below the wing, however, was not changing its speed, so the pressure upward—the part of its sideway pressure we were interested in—was remaining unchanged. Therefore the wing was being pushed up, or at least supported, because the air pressure pushing up on its bottom was greater than the air pressure pushing down on its top. And all this resulted because of the shape of the wing.

"Look, Pa. I'm tearing a two inch strip from the long side of this sheet of paper. I'm bending down a few inches of its length, and holding that part in front of my chin. Notice the rest of the strip, the longer part, is drooping. Now, I'm blowing. . . did you see the longer part rise? The bent part in front of my chin takes the place of a curved surface in making sure the air above the paper is going forward faster than the air underneath. That makes the sideway pressure on top of the paper less than the sideway pressure on the bottom of the paper. So the paper is pushed up.

"Now, Pa, there's another factor involved in lift, although its a less important factor. It's called kite effect. What's that, Pa? O.K., we'll talk about it some other time."

CHIPPED GLASS FLORAL DESIGNS

The floral design on chipped glass is made with glue. Animal glue is poured on glean glass and allowed to dry. Glue adheres to the glass and as it dries, it shrinks and wants to curl upwards. It has tremendous tensile strength and in curling upwards, it pulls pieces of glass with it leaving the glass with a floral design. The size of chips or design is controlled partly by the grade of glue used.

CHILDREN'S INTERESTS IN SCIENCE AS INDICATED BY CHOICES OF READING MATERIALS

VIVIAN D. VON QUALEN AND PAUL E. KAMBLY
University Elementary School, Iowa City, Iowa

A review of the research that has been carried on to discover children's interests in science shows that there have been several different approaches to this problem. The most common methods used to determine children's interests in science have been questionnaires, question methods, and laboratory methods. Those using the questionnaire method have asked children to designate choices of scientific topics; the question method has utilized tabulations of children's questions for specified periods of time, and these questions were used with the assumption that the topics about which most questions were asked were those most interesting to the children; the laboratory method has been used in such a way as to allow children to choose certain objects that they would like to study, talk, or write about.

In 1870 Bartholomai (8), a German, published an account concerning the scientific knowledge that children had when they entered school. His object was to discover deficiencies in children's experiences to be used in planning science instruction. In the same year Dr. Karl Longe (8) also attempted to find a basis for instruction by asking eight hundred children who were just entering school simple questions on scientific topics. In 1880 G. Stanley Hall (3) began an investigation in which he made use of one hundred sixty-two ideas and objects in questioning children. In 1904 Trafton (9) found in a study made in grades four through eight and involving almost one thousand children in New Jersey that children's acquaintance with nature is limited; that younger children are impressed by the appearance of animals, and that activities of animals are most impressive in the upper grades. In 1910 Libbey (3) made a comparative study to determine information possessed by children from the first grade through ninth grade; he also compared white and colored pupils. In 1912 Mau (4) carried on an investigation in Chicago schools in kindergarten and in grades one, two, and three. The purpose of this investigation was to discover the kind of object preferred by children with regard to age and sex. She used a pepper plant with red peppers on it, a gray cat, and a toy engine with complete works; the children were allowed to choose whichever they preferred. Her

experiment indicated that these children were interested in physical phenomena as well as plant and animal life, and that younger children were especially motor sensory. Downing (1) also made a study of children's interests in nature materials in 1912; he reviewed the questions voluntarily asked by children in the columns "Because We Want To Know" in *St. Nicholas* magazine over a twelve year period. In a review of four hundred forty-seven questions and two hundred ninety-five observations from seven hundred thirty-two children of which three hundred one were boys with an average age of 11.9 years and of which four hundred thirty-one were girls with an average age of 12.08 years, he found that 61% of the questions were about animals, 20.6% were about plants, 11.6% were about physical materials and 1.8% were miscellaneous. In 1921 Finley (2) carried on an experiment in eight grades in seven schools of a wide range of types for the purpose of determining children's interests in science. A North American salamander, commonly called a "Mud Puppy," was taken into the rooms; and after pupils looked at the animal in groups of seven for three minutes, they were asked to make a list of things that they would like to know about it. Forty days after the mud puppy had been discussed, the children were asked to write a composition on it; the compositions written showed a close similarity to the questions that had been asked, so that Finley felt that in his experiment children's questions were indicative of their interests. He later carried on an experiment in five elementary schools in grades three through eight for the purpose of discovering pupils' interests in plants, animals, and physical phenomena. Each of the above phases was presented in a single class exercise with an effort to stress each phase equally. On the following day pupils were asked to write on any one of these phases. In the final results the bird received first choice, the plant second, and the pendulum third. In 1921 Palmer (7) began a series of question collecting studies through the medium of the *Rural School Leaflet*. Questionnaires were sent to between fifteen and sixteen thousand rural school teachers in the state of New York, in which they were asked to state which nature study questions they were being asked by their pupils. A composite table of the results was published in a leaflet in 1926, and it was found that zoology was the most important field according to the number of questions asked; botany ranked second; inorganic nature ranked third, but there

was a wide gap between this and botany; agriculture ranked last. In 1924 Pollack (10) conducted a study in the eighth grade in Columbus, Ohio. In this study children were asked to list five things in which they were most interested or to ask five questions. He ranked the three thousand five hundred questions into forty-two ranks with electricity heading the list. Plants ranked 9.5; animals and trees ranked 23.5, and engines ranked 36.5. In 1929 Stevenson (9) carried out an experiment in San Jose, California, in grades four, five, and six, using one hundred nineteen children. He used questions, compositions, observations, and rating sheets in order to find children's interests in nature materials. In interpreting his data he found that animals that were alive interested the children most, that unusual things grip the interest of children, and that children's interests vary with age. In 1931 Nettels (6) attempted to find science interests of junior high school pupils by asking one thousand sixty-seven pupils to list five different things in science about which they would like to learn. He classified the intelligence of the pupils as inferior, average, and superior; and when comparing groups within each sex he had difficulty in finding significant differences. However, when he compared the interests of the several groups of boys and girls, he found real differences. In 1933 Mahoney (8) analyzed six thousand five hundred sixty-one questions of children in grades four, five, and six and found that as a whole children were more interested in biological sciences than in physical sciences, but that from the fourth to the sixth grade there was a gradual shift of interest from the biological sciences to the physical sciences. In 1931 Mullen (5) carried on a study in New York City in which she allowed children to make observations of animals and to ask questions. She used these questions to discover the chief interests of children in regard to animals and found that the interests centered around: (1) food and drink and eating (2) actions of the animal (3) points of structure of the animal (4) color of the animal and (5) resemblance of the animal to some other animal or to some inanimate object.

This review of research substantiates the statement that there have been many different approaches to the problem of determining children's interests in science. The authors know of no published reports of studies to discover children's interests in science as determined by their choices of reading materials. A study, the report of which follows, was made in grades four,

five, and six of the University Elementary School at the State University of Iowa in an attempt to determine the scientific interests of children as indicated by their choices of reading materials. The thesis upon which this article is based is on file in the Education Library at the State University of Iowa.

In selecting the one hundred seventeen books used in this study an effort was made to have as wide a selection of content as was possible. The books were classified according to the following thirteen subject matter areas: Ancient Animals, Living Animals, Astronomy, Cloth, Conservation, Earth's Crust, Electricity and Magnetism, Light, Plants, Science and Industry, Transportation, and Weather; the remaining books which did not fit any of the above classifications were classified as General Science. An attempt was made to choose the books so that they included a wide range of reading levels.

In preparation for the study a small book card with the title of the book was placed inside the cover of each book. The books were first placed on tables in the back of the fourth grade room. Before the children were allowed to use the books they were given this introduction: "The principal and teachers of the University Elementary School are often confronted with the problem of selecting books; this time we are asking your help. Since ordinarily the best books are perhaps the books that you like, we are interested in knowing which of the books that are on the tables in the back of the room you like. These books are related to scientific topics. The way that you can help is to choose a book, take it to your seat, write your name on the slip of paper inside the cover, and examine the book. If it interests you, read it; if it does not interest you, return the book and choose another. Follow the rules that you follow during free reading periods. Read it to yourself. Keep the record in each book that you examine. No one will be permitted to use any book during this period except the books that are on the table in the back of the room."

The books were left in the room for a forty-minute period. Later the same procedure was followed in grades five and six. After the children in each room had used the books in the manner described above for two forty-minute periods, they were asked in each of the following five periods to record the time that each book was taken. Books were returned to either the room teacher or to the experimenter. The time when the book was returned was designated and the book was again returned

to the table. A careful check was made of those pupils suspected of being unable to read a clock accurately. Time of use was not recorded during the first two periods that the books were used because it was felt that during these initial periods the pupils would be more interested in examining many books than in reading any single book. Even though they liked a book, many pupils may have returned their books in exchange for another because they were anxious to see as many books as was possible. After they had had access to the books for two periods it was felt that they had seen most of the books and were now ready to read those books that were interesting to them.

Finally, the books were taken again into each room; and as each book was shown to the group, each child designated one of the following about the book: (1) liked it (2) didn't like it (3) didn't examine it, or (4) wanted the book but didn't have a chance to use it.

In summary, the procedure was as follows:

(1) Pupils in grades four, five, and six had access to the books for two forty-minute periods without any attempt to record time of use.

(2) Pupils in grades four, five, and six had the books for five forty-minute periods during which time a record of the time was kept that each book was used.

(3) Each child's reaction to each book was obtained by asking him to check an evaluation sheet.

From the records kept of the number of minutes that each book was used during the five forty-minute periods the average number of minutes that each book was kept per person and the average number of minutes spent on each book in the area were computed. These averages were used to find the rank of each subject matter area according to the data secured from the uses made of the books. The rank according to the percentage of pupils who said they liked the books in these subject matter areas was determined from the data obtained from the evaluation sheets mentioned above. These data are summarized in the following three tables.

It should be obvious that in a study of children's interests, such as has been reported in the previous pages, there are a number of uncontrolled variables. Although there was an attempt made to provide for individual differences in reading ability, there is no claim that differences in reading abilities were adequately provided for in the books used. Books were

TABLE I. COMPOSITE TABLE SUMMARIZING DATA ON RANK OF FREQUENCY, TIME AND QUESTIONNAIRE
GRADE 4

Subject Matter Area	Rank Average number of minutes each book was kept per person			Rank Average number of minutes spent on each book in area			Rank Percentage of pupils who liked this subject matter area		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1. Ancient Animals	2	7	2	1	6	1	1	4	2
2. Living Animals	6	6	7	5	5	5	9	9	9
3. Astronomy	1	12	1	13	12	13	11	13	12
4. Cloth	13	5	11	7	4	6	3	1	1
5. Conservation	3	10	8	2	9	4	12	7	11
6. Earth's Crust	11	2	9	11	7	11	7	11	7
7. Electricity and Magnetism	8	11	12	6	11	10	5	8	5
8. General Science	4	8	6	4	10	8	10	12	13
9. Light	12	4	4	12	2	7	13	5	10
10. Plants	10	9	13	9	8	9	4	2	4
11. Science and Industry	7	1	3	8	1	3	6	6	6
12. Transportation	5	3	5	3	3	2	2	3	3
13. Weather	9	13	10	10	13	12	8	10	8

TABLE II. COMPOSITE TABLE SUMMARIZING DATA ON RANK OF FREQUENCY, TIME AND QUESTIONNAIRE
GRADE 5

Subject Matter Area	Rank Average number of minutes each book was kept per person			Rank Average number of minutes spent on each book in area			Rank Percentage of pupils who liked this subject matter area		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1. Ancient Animals	2	6	7	5	1	3	2	2	1
2. Living Animals	5	3	6	6	3	4	5	7	5
3. Astronomy	8	2	8	8	7	10	7	13	11
4. Cloth	9	11	12	13	12	13	10	4	8
5. Conservation	1	5	1	3	6	5	11	8	12
6. Earth's Crust	13	10	13	12	8	11	8	9	9
7. Electricity and Magnetism	4	12	4	1	10	1	1	5	2
8. General Science	3	7	3	2	5	2	4	6	3
9. Light	10	1	2	10	2	7	9	11	10
10. Plants	11	9	11	11	9	12	12	3	13
11. Science and Industry	6	8	5	7	11	8	6	10	7
12. Transportation	7	13	9	4	13	6	3	12	4
13. Weather	12	4	10	9	4	9	13	1	6

chosen with a wide variation of content in such numbers as to give as nearly equal emphasis as was possible to the different subject matter areas. However, some subject matter areas were represented by more books than others. It is also undoubtedly true that some books were more attractive to the children because of their physical make-up and the style in which they

TABLE III. COMPOSITE TABLE SUMMARIZING DATA ON RANK OF FREQUENCY, TIME AND QUESTIONNAIRE
GRADE 6

Subject Matter Area	Rank Average number of minutes each book was kept per person			Rank Average number of minutes spent on each book in area			Rank Percentage of pupils who liked this subject matter area		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1. Ancient Animals	4	12	7	1	7	1	1	1	1
2. Living Animals	3	2	4	3	2	3	7	4	5
3. Astronomy	6	3	2	10	6	9	13	8	12
4. Cloth	12	9	13	11	10	11	2	3	2
5. Conservation	1	1	1	5	1	4	10	7	10
6. Earth's Crust	8	7	8	12	13	13	11	9	11
7. Electricity and Magnetism	10	11	11	2	12	7	3	10	4
8. General Science	2	5	3	8	4	2	8	13	9
9. Light	11	13	12	4	11	8	9	2	6
10. Plants	13	8	10	13	9	12	6	6	7
11. Science and Industry	7	6	6	7	3	5	4	5	3
12. Transportation	5	4	5	6	5	6	5	12	8
13. Weather	9	10	9	9	8	10	12	11	13

were written rather than because of the topics which they discussed.

In spite of the above mentioned possibilities certain facts remain clear:

1. Fourth grade girls showed most interest in Science and Industry, Transportation, Cloth, Light, and Ancient Animals.

2. Fourth grade boys showed most interest in Ancient Animals and Transportation.

3. Pupils of the fourth grade, considering both girls and boys, showed most interest in Ancient Animals, Transportation, and Science and Industry.

4. Fifth grade girls showed most interest in Weather, Ancient Animals, Living Animals, and General Science.

5. Fifth grade boys showed most interest in Electricity and Magnetism, Ancient Animals, General Science, Transportation, Living Animals, and Science and Industry.

6. Pupils of the fifth grade, considering both girls and boys, showed most interest in Electricity and Magnetism, General Science, Ancient Animals, and Living Animals.

7. The sixth grade girls showed most interest in Living Animals, Conservation, and Science and Industry.

8. The sixth grade boys showed most interest in Ancient Animals, Living Animals, Transportation, General Science, and Science and Industry.

9. Pupils of the sixth grade, considering both girls and boys, showed most interest in Ancient Animals, Living Animals, and Science and Industry.

The following more general conclusions seem justifiable on the basis of this study of children's interests in science as indicated by their choices of reading materials.

1. Pupils in the intermediate grades in the University Elementary School have a wide variety of interests.

2. The girls in the intermediate grades showed most interest in the following subject matter areas: Living Animals, Ancient Animals, Light, Science and Industry, Conservation, Cloth, Transportation, General Science, and Weather; the subject matter areas in which the girls showed least interest were Plants, Astronomy, Earth's Crust, and Electricity and Magnetism.

3. The boys in the intermediate grades showed most interest in the following subject matter areas: Ancient Animals, Transportation, Electricity and Magnetism, General Science, Living Animals, and Science and Industry; the boys showed least interest in Conservation, Cloth, Astronomy, Plants, Light, Weather, and Earth's Crust.

4. In considering all the pupils in the intermediate grades of the University Elementary School the most interest was shown in the following subject matter areas: Ancient Animals, Science and Industry, Transportation, General Science, Living Animals, and Electricity and Magnetism. The subject matter areas in which the pupils showed least interest were Conservation, Light, Cloth, Astronomy, Weather, Plants, and Earth's Crust.

Bibliography

1. Downing, R. Elliot: "Children's Interest in Nature Materials," *Nature Study Review*, 8: 334–338, Dec., 1912.
2. Finley, Charles W.: "Some Studies of Children's Interests in Science Materials," School Science and Mathematics, 21: 1–24, Jan., 1921.
3. Hillman, James E.: "Some Aspects of Science in the Elementary Schools," *Contributions to Education*, No. 14, Peabody College for Teachers, Tennessee, 1924.
4. Mau, Laura E.: "Some Experiments with Regard to the Relative Interest of Children in Physical and Biological Nature Materials in the Kindergarten and Primary Grades," *Nature Study Review*, 8: 285–291, Nov., 1912.
5. Mullen, Rosemary F.: "An Analysis of the Mental Reactions of Children at Different Grade Levels to Certain Living Animals," *Science Education*, 23: 361–366, Nov., 1939.
6. Nettels, Charles H.: "Science Interests of Junior-High Pupils," *Science Education*, 15: 219–225, May 1931.

7. Palmer, E. Lawrence: "How to Meet Some of Children's Nature Interests," *Nature Study Review*, 18: 23–30, Jan., Feb., 1922.
8. Robertson, Martin L.: "A Review and Evaluation of the Curricular Studies Pertaining to Elementary Science," *Science Education*, 18: 86–93, April, 1934.
9. Stevenson, Elmo N.: "Children's Nature Interests," *Elementary School Journal*, 32: 276–284, Dec., 1931.
10. Underhill, Orra E.: *The Origins and Development of Elementary School Science*, Scott, Foresman and Co., Chicago, 1941.

NEW PUBLICATION ON HEALTH EDUCATION

A new publication, dealing with ideas for the improvement of high-school teaching in health education, was announced today by the U. S. Office of Education, Federal Security Agency.

More Firepower for Health Education, Bulletin 1945, No. 2, is a 50-page bulletin prepared especially for high-school teachers. Its purpose, according to the author, is to help teachers become more skillful in working with feelings to the end that more knowledge will be translated into ways of living. The author, Arthur H. Steinhaus, was formerly Chief, Division of Physical Education and Health Activities, U. S. Office of Education.

The publication is not intended as a course outline or a listing of what should be taught, but is an attempt to illustrate methods that may help to close the gap which often exists between the health knowledge and the health behavior of individuals. It stresses the idea that the success of any educative experience varies as thoughts are or are not accompanied by appropriate feelings; that education must ever be alert to both of these happenings; and that the teacher can influence the feeling phase of an experience even as he can influence the cognitive phase.

Consideration is given to the significance of attitudes, what they are, how they are made, remade, and renovated, and how they are adapted. Certain sections of the study deal with pain and the fear of pain, satisfactions from doing and serving, the teacher as a motivator, and as a human being. Numerous illustrations, some of which are reproductions of health posters designed by students, have been used to supplement the text.

Copies of *More Firepower for Health Education*, Bulletin 1945, No. 2, may be obtained by purchase at 15 cents each, from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

WANTED: DENTISTS, DIETITIANS, MEDICAL SOCIAL WORKERS

Veterans Administration hospitals throughout the country are in need of dentists, student dietitians, psychiatric and medical social workers, according to information received today by the regional office of the U. S. Civil Service Commission in the New Post Office Building, Chicago.

Dentists are paid $3,640 a year. Student dietitians begin at $1,704, are promoted after six months of satisfactory service and after a year of service are eligible for appointment as staff dietitian at $2,100 or $2,320 a year.

Psychiatric and medical social workers who attain supervisory qualifications are paid as high as $4,300 a year.

Announcements and application forms may be obtained from the regional office of the U. S. Civil Service Commission or from any first- or second-class post office. Applications should be sent to the U. S. Civil Service Commission, Washington 25, D. C.

MASTERY OF THE FUNDAMENTALS OF HIGH SCHOOL MATHEMATICS: A GRADUATION REQUIREMENT

E. R. BRESLICH
The University of Chicago

(Concluded from November)

THE PLACE OF MATHEMATICS IN THE AMERICAN HIGH SCHOOL

In view of the widespread uses of mathematics the question may be raised: To what extent, in the past, have the values of high school mathematics been recognized by the school authorities and what should be the future attitude toward that subject by the pupils and by those who advise them in regard to the choice of subjects they should take?

The American high school developed in response to the needs of society. Its record shows that it has constantly aimed to serve the needs of society. It is significant that among the first subjects securing prominent places on the curriculum were two taken from the field of mathematics, algebra and geometry. Trigonometry was added later.

Mathematics held its position for a long time because of its usefulness. To a large extent its popularity was due also to the great disciplinary value which it was supposed to possess. For, the belief was widespread among parents and school administrators that the study of mathematics automatically sharpened the mind of the learner.

When the newer subjects, the sciences and the arts, began to seek places on the curriculum the values of mathematics were being questioned and its position was endangered. Nevertheless up to about 1910 the popularity of mathematics continued to increase. At that time approximately 57 per cent of the pupils were taking algebra and 30 per cent geometry. After 1910 the percentages of pupils taking algebra and geometry decreased. By 1934 they had dropped to 30 and 17 per cent, respectively. The decrease has been explained by some as the result of a persistent campaign against the mathematics of the high school. Many school systems dropped, or at least lowered the mathematical requirements for graduation. State requirements were eliminated. Colleges fell in line by lowering entrance requirements. As the emphasis on mathematics decreased new subjects were admitted to "broaden" the pupils' program. In time they

replaced mathematics. Yet, today mathematics is needed by millions. They use it in industry, in the professions, in business, in commerce and in the affairs of everyday life.

When war came one of the serious problems facing the military authorities and the great war industries arose from the shortage of men and women with sufficient mathematical background. Thousands who were eager to enlist in the Army and Navy, to take important positions in the industries as skilled workers, to engage in research, failed to qualify because they were lacking in mathematical requirements. They needed the mathematics of the high school: arithmetic, algebra, geometry and trigonometry. Why is it that while mathematics is needed more than formerly in American life, while modern civilization is becoming more complex and more mathematical, many schools are dropping all mathematical requirements, and the percentage of pupils taking the subject is steadily on the decrease.

It is not the first time that we have had this experience. It happened after World War I, although not to as great an extent. The lesson was soon forgotten then. Will it be remembered after the present war?

Criticisms Tending to Reduce the Popularity of High School Mathematics

When arguments against mathematics arise in a group of parents or educators one of the most frequent comments is that the "teaching of mathematics has been inadequate." No one will deny that there have been in the past and that there always will be poor teachers as well as good teachers of mathematics, or of any other school subject. Indeed, often classes in mathematics are being taught by men and women who have not even prepared themselves to teach the subject. However, if that group is excluded, the claim that the decrease in the popularity of mathematics has been caused by inadequate teaching must be regarded as a criticism of the teachers of mathematics as a group.

There is no evidence that the quality of teaching has been on the decrease since 1910, but there is ample evidence that it has been on the increase. At the turn of the century the requirements for teaching were so low that college graduates with a bachelor of arts degree were considered qualified to teach mathematics. The remark was commonly made that "anyone can teach mathematics." Since then the requirements for teaching have been

raised to the point where today school administrators expect mathematics teachers to be trained in their own subject and also in one or more related subjects. This means that they will know enough about the uses and applications of mathematics in other fields to make the study interesting and appealing to the pupils. Courses in methods of teaching and in student teaching while in college, give them a working knowledge of the psychology of mathematics and acquaint them with the most effective teaching procedures. It gives them the necessary information about the pupil's learning process so as to better understand the difficulties encountered by the pupils. Most important of all, they have been taught how to deal with the problems which they will encounter later in their own classrooms.

The training of teachers continues when they are in service. They may study during vacation time. They may join one or more of the national mathematics associations whose meetings are devoted to the problems of the teacher. They accumulate home libraries of books on methods, mathematical journals and yearbooks which they may consult for answers to their teaching problems. Surely, there can be no basis for the claim that the teaching of mathematics has deteriorated during the decade in which the preparation for teaching has made such advances.

Furthermore, while no evidence has been produced which shows that the teachers of mathematics are inferior to those of other subjects, some studies have shown that when compared with other groups, the teachers of mathematics rank high in such qualities as general culture, reasoning ability and professional information.

Some pupils avoid courses in high school mathematics because they have been told that a "special ability is required to study that subject." In all mathematics progress is necessarily slow because each step is built upon preceding steps. One who for one reason or other omits parts of the work finds progress slow and difficult while these parts are being made up. However, the conclusion to be drawn is that interruptions should be avoided if at all possible, not that the study of high school mathematics is too difficult.

To determine causes of difficulty on the part of pupils taking mathematics one school made a study of the weekly pupil reports submitted by the teachers to the principal. Three chief causes of failure were reported: poor attitude, lack of the necessary effort, and frequent absences from class. Only seldom a

teacher named lack of ability. Many took the trouble to explain that the pupil had the ability and would have no difficulty if he could be induced to apply himself to the work. Experience seems to show that when a pupil does passing work in his other subjects but falls down in mathematics the causes are other than lack of mathematical ability.

To tell normal pupils who have difficulty with mathematics that they are lacking in ability is not without danger. Some who could profit from the study but prefer an easy time will make it an excuse for substituting another subject which requires less mental effort. Others accept without challenge the verdict that they have no mathematical ability and develop an inferiority complex. Teachers should be slow in deciding that pupils are lacking in ability, and should endeavor to find the causes actually responsible for failure. Much is being done in the modern school to reduce or eliminate failure. Allowance is made in teaching for differences in progress, and corrective work is done to aid the slow pupils. Textbooks are being improved. The work is carefully graded. It is motivated by showing the uses of the subject. The language of the textbook is that of the pupil, not the language of the scientist.

There was a time when it was thought that arithmetic was too difficult for the common people and that a special arithmetical ability was needed to master that subject. Yet, today all elementary school pupils learn to master the arithmetic processes. The time will come when the basic ideas and processes of high school mathematics will be mastered by all, and not only by a small percentage of the population.

It has been claimed that "pupils in general dislike mathematics." This does not agree with the findings of several studies that have been made to determine the attitudes of high school pupils toward school work in general. They disclose the interesting fact that mathematics is both the best liked subject and the least liked. The successful pupils find it stimulating and interesting and feel that they are greatly benefited. Those who dislike it say that they do not understand it and do not derive any benefit.

Those who understand it usually enjoy it but it is also found that some who do not understand, or at least find it difficult, enjoy it regardlessly. Studies of cases of pupils who say that they thoroughly dislike mathematics, disclose that lack of understanding is the greatest contributing factor, but not the only

one. Some dislike mathematics because they dislike all school work. Others dislike it because they have no taste for any kind of work which requires continuous effort. They find it difficult to return to mathematics, if for some reason they have neglected it temporarily. People in general hold mathematics in high respect even those who had little success with it in school. They know from experience that the subject has real value in everyday life and in the work which is their vocation.

While it is admitted that most of the content of high school mathematics is useful and valuable the assertion is often made that "courses in mathematics contain an abundance of material which people in general do not use." Why then should a pupil study such material? Usually the objection comes from those who do not understand the reasons for retaining materials that seem to have no direct practical value. They do not know that since the turn of the century teachers of mathematics, authors of textbooks, national committees and other groups have examined and reexamined the offerings of the department, and much that has no immediate value has been deferred to higher courses. On the other hand, materials of the upper courses that are not too difficult, possess practical values and should be used, have been brought down. What people in general use may not be nearly as important as what they should use.

Some materials that have no immediate practical value must be retained because they are needed in the development of the subject. Thus, we may say that the formula $(a+b)^2=a^2+2ab+b^2$ is a useless piece of information and should therefore be eliminated but that the compound interest formula $A=C(1+i)^n$ has practical values, because with the aid of a logarithmic table a person can find in a few minutes the amount for any given number of years n, at any given rate of interest i, of an invested capital C, while a person not acquainted with it may spend hours in arithmetic summation and multiplication to find the result by arithmetic. The fact is that the study of the first formula is really a step toward the development and understanding of the second.

It is true that the traditional sequential courses in high school mathematics often carry the learner beyond every day needs and even beyond vocational needs. Yet, these courses will always be needed by those who plan a college education, as future engineers, scientists, men and women doing research, and those to enter the professions. Even in the high school a knowledge of

algebra and geometry is essential to the successful pursuit of other subjects, especially the sciences and arts. For those who are interested in mathematics only to meet general everyday needs other courses are available, for example, the courses in "general" mathematics. No pupil should deliberately omit all mathematics in the high school. He may be missing an opportunity which may never again present itself.

It has been found that the percentage of former students who regret not to have taken more high school mathematics is as high as 40 or above. Surely the fact that so many are feeling the lack of mathematical education in the work they are doing as adults should give parents and school administrators something serious to think about. Such arguments as "you will never need mathematics because I am getting on very well without it," or "Why bother with such a useless subject as mathematics?" have been too costly to many pupils with real mechanical ability who failed to acquire a working knowledge of mathematics needed in their vocations.

Frequently pupils have been told that if they should need mathematics in their vocations "they will be taught what is necessary when they learn the job." Some stores teach prospective clerks to make out bills, to total sales slips, and to add the sales tax. In the industries unskilled workmen make but slight use of mathematics and in many jobs they are taught the mathematics they need. In an emergency even skilled workmen in some jobs are being shown how to find algebraic and trigonometric formulas in handbooks and tables and how to use them. But this training can never be the equivalent of that attained in the classroom with its opportunities and time for questions and discussions. A man can be taught to sell a radio, a washing machine, or even a heating plant without knowing much mathematics but when a customer planning the installment of a new heating plant wants the amount and cost of materials the job has to be turned over to one who knows more mathematics. A worker who knows just enough mathematics to make tools and machines may be able to hold his job, but he has no chance for training in planning and designing tools and machines. That job goes to a person with better mathematical preparation. The worker who has ambition to rise above the skilled workman, to become a designer, supervisor, or director may never have an opportunity as long as he does not have the required mathematical training.

Unfortunately, the importance of mathematical training is not always known. Many parents treat the fact that their children are failing in mathematics as a matter of little concern. "We could not do mathematics" they tell them, "and we have been getting on very well without it." Some even boast "We never could do mathematics. We have a secretary for that." But how are they really getting on when they encounter problems that have to be solved on the spot and cannot be turned over to a secretary? Any one who observes such people as they deal with the quantitative problems of every day life, the office, shop, store, or home finds them confused and bewildered.

The foregoing arguments against mathematics are typical. The list is by no means complete. Invariably, they are not based upon facts. However, one very serious criticism should be of concern to all teachers of mathematics. It cannot be waived aside with indifference. There has been a persistent complaint that "high school graduates do not know the fundamentals of mathematics and that those who know them are not able to use them correctly in applications." This criticism comes from men engaged in business and industry, from teachers of various school subjects, from teachers of college mathematics, and recently from men in the Army and Navy. These people know and believe in the importance of mathematics. Moreover, there is ample evidence that the criticism is justified, a large amount having been supplied in studies made by those who teach mathematics. If the values of mathematics are not being attained by the pupils, what right have teachers to demand that an even greater number of pupils, perhaps all pupils, be urged to study the subject?

Major Problems for the Post-War Period

In the foregoing pages it has been shown that mathematics grew out of the needs of man; at all times mathematics and civilization have been linked together; in the future, as today, mathematics will be no longer the need of only a small group; hence more pupils should be induced to study the subject. On the other hand, during the last three decades the popularity of mathematics has been on the decrease, and the criticism persists that high school pupils do not acquire the fundamentals of mathematics. Hence, some of the most pressing problems of the post-war period are: to develop ways of aiding pupils

in the acquisition of the fundamentals of high school mathematics, to develop the ability to use these fundamentals in solving problems; and to reestablish the former popularity of mathematics among high school pupils.

The war has awakened a new interest in mathematics. Never has that subject been in as strong and advantageous position as today. The time has come therefore to give the solution of these problems immediate attention. It will be no easy matter, but it should not be impossible to find solutions. Nor is it a task that can be performed by the teachers alone. They need support if anything like nation-wide attainment of these objectives is to be attained.

Not that the teachers have not received help in the past. Great advances have been made in textbooks; in books on methods of teaching filled with discussions of effective teaching procedures; in the mathematical journals and yearbooks of the national associations and the reports and yearbooks of national committees and commissions. Indeed, it is not a question of scarcity of aids that troubles the teacher, rather one of abundance. The right kind of aid has been overlooked or has not yet been found.

To illustrate, since 1923 reports have been made by more than half a dozen of national committees. Each gives evidence of a great deal of hard work. Each has formulated excellent and helpful recommendations to aid the class room teacher. Now one of the first steps in the process of teaching for mastery of the fundamentals will be to plan, or choose a plan of organization of materials. Consulting the reports the teacher finds that the *Committee of 1923* submits five plans of organizing courses for the junior high school. The *Joint Commission of 1940* presents two plans for the junior and senior high schools. The *Cooperative Committee on Science Teaching of 1943* recommends three plans. The *Commission on Post-War Plans of 1945* advocates a double track plan for the ninth grade. To select the plan most suitable for his purposes the teacher will find it necessary to make a study of these recommendations. He may have to work out a combination of several of the plans. He may even undertake to organize a new plan of his own. He may retain some recommendations and discard others. For example, he may decide that a plan which attempts to crowd all the fundamentals into a single year's work will not solve the problem. Furthermore, the plan he needs must be so definite

and detailed that it is worthy and capable of country wide adoption.

Evidently, the task is more than a busy teacher or department can carry. It is a job for a group of men and women qualified to make decisions with authority and recognized as leaders in the field of mathematics.

Another step in the solution of the problem is to select a list of "fundamentals" which all pupils are expected to master. What are these fundamentals? Vaguely some writers speak of "basic concepts, skills and principles of arithmetic and algebra, informal geometry and numerical trigonometry." The teacher who is pledged to secure proficiency in the fundamentals needs something much more specific. Turning to the national committee reports he will receive some help. The *Committee of 1923* lists nine topics of essentials in arithmetic for grades 7, 8 and 9, seven topics for informal geometry, five for algebra, and four for numerical trigonometry. The *Joint Commission* gives typical lists of "essentials for seven mathematical fields and types of training and appreciation." The *Commission on Post-War Plans* expresses the essentials for functional competence in mathematics in the form of 28 questions. A rather complete list is found in the report of the *Committee on Essential Mathematics for Minimum Army and Navy Needs.*

The latter may come near a satisfactory list of essentials for the needs of citizens in general. The committee which made up the list had to be specific. For they had in mind a particular objective: to satisfy military needs. Moreover, for the purpose of clearness they went a step farther and supplemented each topic with a verbal explanation or example to illustrate what they meant. A list of this type should be really useful to the teacher who is aiming for mastery of the fundamentals of mathematics.

It must be clear then that if the teachers of mathematics are to solve the problem of securing mastery the ground work must be done by a group of experts, perhaps another committee appointed by the national organizations, or by some existing committee.

Still another step in the solution of the problem is to determine the grade levels at which mastery of the specific fundamentals is to be attained by the pupils. Then the teacher of any course using any texbook can keep a continual check on the progress and accomplishments of the pupils. This was recog-

nized by the *Joint Commission*. By giving the grade placements they show when the various essentials are to be attained.

Finally it will be necessary to set up a program of testing, evaluating and corrective work with the pupils to determine when they have become proficient in the fundamentals and the extent to which they are able to use them in applications.

It should not be inferred from the foregoing discussion that the whole problem is to be dropped into the lap of a committee. No matter how excellent the report of a committee might be its value and influence will be slight without some very careful planning to gain for it the country wide support of the mathematics teachers in the high schools, colleges, and schools of education; of the writers on mathematical subjects; of the editors of the national mathematical journals; and of the associations of mathematicians and of teachers in other fields interested in mathematics.

For example, what can the teachers of mathematics contribute? Teaching for mastery should not be directed alone toward manipulative skills. Important information is to be acquired. Understandings of concepts and principles must be attained. Mathematical habits are to be developed. Pupils must learn how to use mathematics in new situations by using it in a variety of applications. Learning must be stressed. Pupils should be led to appreciate the active and useful phases of mathematics in social living.

Such objectives are not attained automatically by themselves. They require a familiarity with the values and uses of mathematics. Classroom work must be illustrated with applications selected from vocations and everyday life. Pupils must be inspired to study the subject while they have the chance in school. All of this necessitates wide reading, especially of the mathematical journals, committee reports, and yearbooks. The teacher who is genuinely interested in his subject will receive inspiration and encouragement by identifying himself with one or more of the national mathematical associations and by attending their meetings whenever he can.

What can the writers on mathematics contribute? In the past they have addressed themselves almost exclusively to teachers of mathematics and education. They have neglected great opportunities for arousing and sustaining the general reader's interest in mathematics. It is well known that people in general are keenly interested in the subject. They read eagerly anything

in the field that is not too technical for them to understand. Such books as Hogben's ***Mathematics for the Million*** and Logsdon's ***A Mathematician Explains*** have been read widely by non-mathematicians. They have done much to break down hostile attitudes toward mathematics.

Is there anything the editors can do? More aid has been given by this group than by any other. They always have allotted space generously in their journals for discussions of committee reports. Thus, in December 1940 the ***Mathematics Teacher*** devoted the entire issue to articles dealing with the two reports that appeared during that year. However, very little of this has reached the general public. Newspapers have carried many editorials and articles on mathematics but the majority are not constructive, critical and often destructive leaving the reader under the impression that high school mathematics is being poorly taught and that the teachers must take the blame for it. A great deal of material appears in the mathematical journals that can be used to correct this impression and that should find its way into the newspapers and non-mathematical magazines. The editors are in the best position to select such materials for distribution.

People enjoy reading about the great achievements made possible by mathematics in the fields of science, engineering, astronomy and aviation; about the applications of mathematics in industry and future vocations of high school pupils; about ways of using mathematics to their advantage in everyday life; and about modern ways of teaching the subject. A single article in a popular magazine may reach a million persons, arouse wide interest and appreciation, and cultivate a friendly attitude.

The teachers of mathematics owe a great debt to the mathematical associations. Relatively few persons are carrying the burden for the great mass of teachers who share in the benefits without contributing anything. The associations have made possible the work of the committees. It is to be deplored that sometimes it takes decades before the improvements recommended by the committees secure country wide adoption. Plans for the work of a national committee are therefore incomplete without planning ways of securing the adoption at least of the most pressing of their recommendations.

The problem of securing mastery of the fundamentals of high school mathematics is sufficiently important to deserve

the immediate attention of teachers, writers, editors and teachers associations. When these groups stand back of the resommendations of a committee of men and women who have made a thorough study of the problem one major criticism of the teaching of mathematics will be eliminated. Then the popularity of the subject among high school pupils will be again on the increase.

A NEW GAS TURBINE LABORATORY AT MIT

A check for $125,000 to aid establishment of a new gas turbine laboratory at the Massachusetts Institute of Technology was recently received by James R. Killian, Jr., Executive Vice President of the Institute, from Frank L. Nason, New England District Manager of the Westinghouse Electric Corporation.

In making the presentation at a luncheon at the Algonquin Club, Mr. Nason said his Company "was glad of the invitation to contribute to the Laboratory Fund because the project has a natural interest, as a result of Westinghouse background, research, and engineering development in the gas turbine field."

The new laboratory, announced yesterday by Dr. Jerome C. Hunsaker, head of the Aeronautical and Mechanical Engineering Depts., will be dedicated to graduate study and research in the gas turbine field—which includes the jet propulsion aircraft engine, the spectacular, war-time aviation development. Prof. Edward S. Taylor will be project engineer for the new enterprise.

TRAINING OFFICERS NEEDED

Returning Veterans under treatment at Hines Veterans Administration hospital near Chicago, Illinois and the Wood Veterans Administration hospital, near Milwaukee, Wis., are wondering about the vocational training they were told that they would get during convalescence.

They ask questions that are hard to answer, according to the authorities at Wood. The facilities are available, it was stated, but a dearth of training officers has limited the fulfillment of the training program.

Circulars are being distributed throughout the states of Illinois and Wisconsin by the United States Civil Service Commission appealing for training officers to work under the general supervision of the vocational rehabilitation officer at Hines and at Wood.

While veterans are preferred to assist in this training program the situation has been declared an emergency and any qualified person who applies for the position will now receive consideration, it was announced.

Even persons who themselves may be handicapped in certain respects but are capable to instruct along certain lines not affected by their limitations are requested to make application. Salaries range from $2,980 to $4,300 a year.

Further information and application forms may be obtained at the regional office of the Civil Service Commission, 433 W. Van Buren St., Chicago; at the Civil Service office in Milwaukee or at any first or second class post office in Illinois and Wisconsin.

THE MODERN AIRCRAFT PROPELLER AND THE PHYSICS COURSE

EUGENE W. GROSS*

A. HISTORY OF THE PROPELLER

Several circumstances make the modern pitch change aircraft propeller a most favorable subject for study in a vitalized physics curriculum. Its operation depends upon the application of classical principles laid down by Isaac Newton and Daniel Bernouilli, among others, and its development is intertwined with the history of physics. Furthermore, certain properties of the atmosphere, such as the "springiness" observed by Robert Boyle, play a part in propulsion. Also, the occurrence of two component air forces in aircraft propeller operation and their resolution into "relative" wind is a practical example of the resolution of forces. And to the physics teacher looking for means for motivating interest in his course, the propeller, as an instrument for advancing the superb performance of aircraft in war and promoting travel in peace, offers rich possibilities.

Contrary to popular opinion, the modern aircraft propeller has a history of conception and development that extends back for many centuries. Over 2,000 years ago, the Chinese became familiar with its performance by spinning the propeller off a

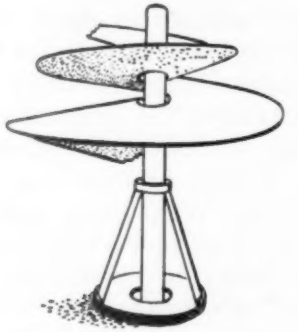


FIG. 1

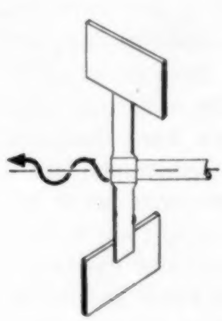


FIG. 2

stick and into the air. During the 15th century, Leonardo da Vinci applied the principle of the screw to a flying machine design. This early propeller, shown in Figure 1, was intended to lift the craft vertically by its screwing action. During the 15th

* Formerly of the Public Relations Department, Propeller Division, Curtiss-Wright Corporation, Montclair, N. J.

and 16th centuries, investigations carried on progressively by Galileo, Torricelli and Pascal established the revolutionary concept of the atmosphere as an example of fluid matter—events that are familiar reading in all physics texts. It was observed that the atmosphere, like all matter, offered resistance to motion, exerted pressure and had density and weight. This concept stimulated contemporary scientists and philosophers to investigate the possibility of travel through the air.

In 1752, Daniel Bernouilli, formulator of the theorem that bears his name, designed a propeller, shown in Figure 2, which differed from da Vinci's concept of the continuous screw. Two paddles, representing two areas of the screw, were attached to a shaft by means of spokes and achieved the same effect as a screw when the shaft was rotated. Lack of engines and construction materials prevented application of this idea.

During the early part of the 19th century, the use of the steam engine in ships inspired considerable activity on the part of propeller inventors who wished to replace paddle wheels with water screws. Each of the designs was fundamentally the same as the Bernouilli propeller, differing only in detail and construction. John Ericsson, the Swedish engineer, in designing a steamship in 1839, made the first commercial application of a screw propeller which consisted of six paddle blades.

The success of nautical propellers led to their application on lighter-than-air craft which were modified in shape from the round balloon to elongated dirigibles to facilitate travel through the air. Because of successful mar[illegible]peration and a lack of knowledge of aerodynamics, practical[illegible] of these early airship propellers were designed similar to marine propellers. This practice continued until the Wright brothers constructed propellers that were to be driven by gasoline engines for propulsion of their flying machine. Their aeronautical investigations and the existing airfoil theory had indicated that a propeller blade should be profiled or curved across its breadth to obtain the maximum reaction when rotated in the air. Thus, the rudimentary fabric-covered frame propellers used by the Wrights in 1903 were the first to incorporate an airfoil shape in recognition of the fact that marine propeller design was inadequate when applied to aeronautical propellers.

By 1909, two bladed propellers were in widespread use, continuing to propel war planes throughout the first World War. During the 1920's, a transition from wood to metal was

effected when planes were equipped with twisted slab propellers made of aluminum alloy. At this time, a final step in the evolution of the modern aircraft propeller was taken when engineers developed a propeller whose blade angles could be altered by rotating the blade shanks in the sockets of the hub. This type of propeller, called a "variable pitch" to distinguish it from its "fixed pitch" predecessor, can claim a large share of the credit for the high performance of modern aircraft. Figure 3 illustrates a propeller mounting three blades whose angle is

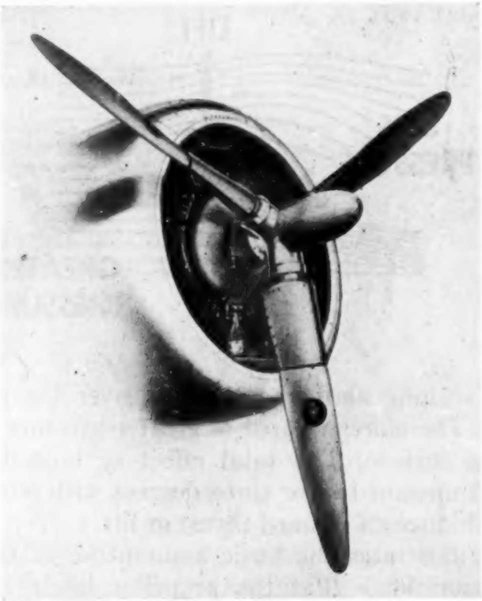


Fig. 3

altered when the shanks are made to rotate in the hub sockets. The principle of a variable blade angle will be discussed at a later point in this article.

B. Theory of Propeller Action

The basic function of the aircraft propeller is to convert engine power into a forward thrust which propels the airplane through the air. To explain propeller thrust, designers often start by comparing a propeller blade to a plane's wing, saying that a blade is simply a rotating airfoil.

The lift force exerted on a moving wing or airfoil becomes intelligible in the light of Bernouilli's and Newton's observations. Bernouilli said that when the velocity of a moving fluid increases, its pressure decreases. The converse is likewise true. As the velocity of a moving fluid decreases, its pressure increases. Figure 4 shows that Bernouilli's theorem can be applied to a tilted wing or airfoil on a moving airplane. The high velocity of the air molecules sliding over the upper curved or camber surface produces a low pressure against that area. Conversely, the tilt of the wing, called the "angle of attack,"

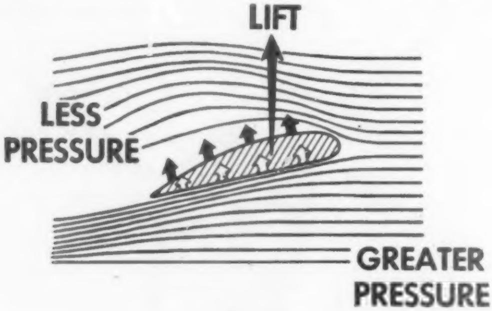


FIG. 4

causes the rushing air to be impeded over the lower flat or thrust side. Therefore, an area of greater pressure is generated against this surface. The total effect of both forces on an airfoil tilted upward two or three degrees with reference to the wing is to produce an upward thrust or lift.

Figure 5 illustrates the basic assumption in the theory of propeller operation,—that the propeller blade is a rotating airfoil, subject to the same conditions and, consequently many of the same forces that act on an airplane wing, but with certain modifications. The wind, which sweeps over and under a wing due to the forward motion of the plane, is created about the propeller blade by the speed of rotation. The plane of the blade lies vertically with reference to the ground, the leading edge being tilted forward rather than upward, as in the wing. Consequently, the region of greater pressure is in back of the propeller blade and against the thrust side; the region of low pressure is in front of the blade and against the camber side. A backwardly directed wind is created. Since this wind is highly compressed by the blade but is very elastic by nature, it resists in a forward direction, trying to enter the area of low

atmospheric pressure in front of the propeller. That is, "For each action there is an equal and opposite reaction," according to Newton. As a result, a forward thrust is produced which shoves the propeller ahead and with it, the plane.

C. The Pitch Change Propeller

The added functions of the modern pitch change propeller which distinguish it from the fixed pitch type that merely produces forward thrust are as follows:

(1) To maintain constant engine speeds for normal operation, (2) To "feather" or rotate the blades so that they lie in line with the wind in case of engine failure. (3) To reverse, by rotation, the angle setting of the blades for the purpose of

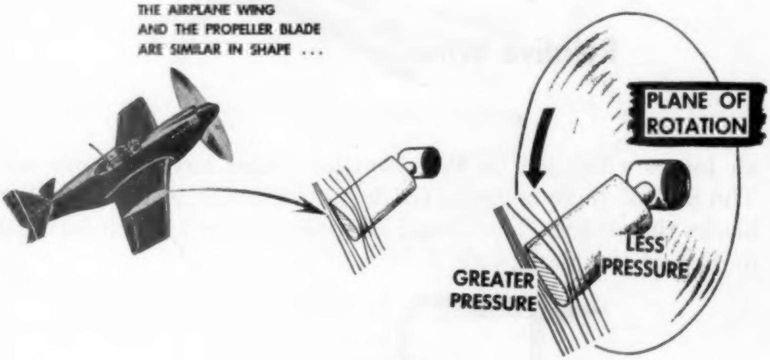


Fig. 5

"aerodynamic" braking during a landing run. The first of these functions will be discussed now and the other two at a later date.

The transition from a propeller with fixed blades (fixed pitch) to one with rotating blades (pitch change) came in response to a need that designers had felt during the first World War. The fixed pitch propeller, they observed, provided only a single blade angle which efficiently absorbed engine power during one set of flight conditions. But for changing conditions which include variations in airplane speed and difference in air pressure, the fixed pitch propeller proved to be inadequate, causing the engine to over- or under-speed. During early developmental stages, the answer to the problem was a propeller in which the angle of the blades could be adjusted on the ground, and then later a pitch change propeller whose blade angles were altered in flight through manual control by the pilot. For the

past decade, however, automatic control of the blade angles through the use of a governor during normal flight has supplanted pilot control.

In explaining the superiority of the pitch change propeller over its fixed pitch predecessor, it must be remembered that the

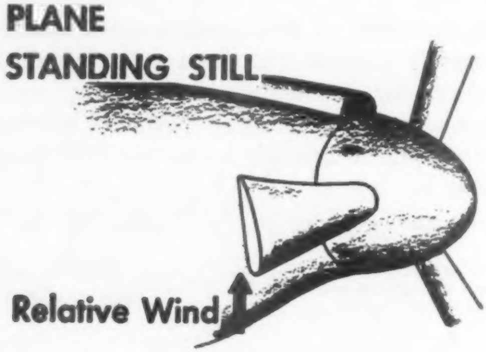


FIG. 6

air forces which act on the propeller blades have two sources. The first of these is generated by the whirling of the propeller blades themselves. The second air force is caused by the forward motion of the plane.

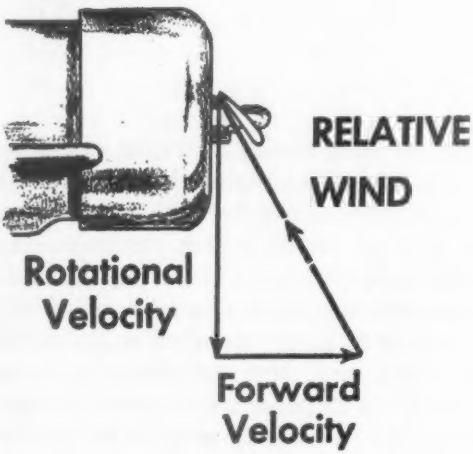


FIG. 7

When the plane is at rest on the ground and the propeller blades are whirling, the plane of rotation is at right angles to the drive shaft. Therefore, a vertical air force or component is set

up. While the planes is at rest, the blade is set at a narrow angle with reference to the vertical component because this narrow angle is the "best one," as shown in Figure 6, to produce the most effective forward thrust. When, however, a plane begins to move forward, as shown in Figure 7, a new force is introduced, a head-on "wind" set up by the forward motion of the plane, thereby constituting a horizontal component. A combination of these two forces, as seen in Figure 7, is resolved into a diagonal relative wind. Since, for a plane that starts to move

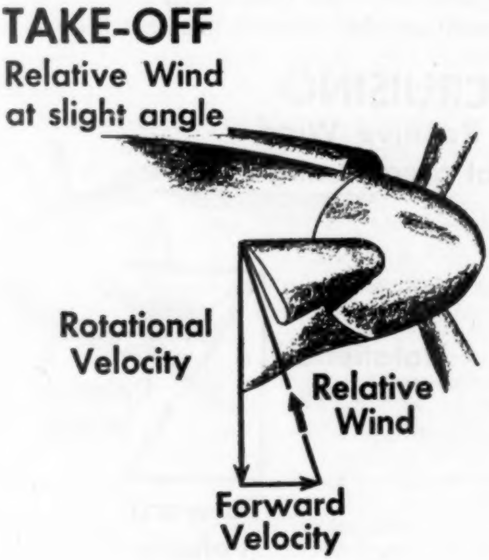


FIG. 8

forward during a take-off, the vertical air force is supplanted by a diagonal relative wind, the blade angle must be raised several degrees in order to "bite" effectively into the air,—Figure 8. At cruising speed or during a dive when the force of the horizontal component is even greater, the blade angle must be raised several more degrees,—Figure 9. If, however, a plane loses speed, as during a climb, the reverse is true. The blade angle must be lowered because the relative wind has shifted "downward" due to diminution in force of the horizontal component.

The angle which the blade makes with reference to the relative wind is called the "angle of attack" and must be distinguished from the "pitch angle." The angle of attack, measured

with reference to the relative wind, always remains the same since it rotates up or down in order to conform to changes in direction of the wing. It is the pitch angle, however, which varies since it is measured against the horizontal, an absolute position.

In one type of pitch change propeller, the blades are made to rotate by means of a small, reversible electric motor located in the nose of the propeller. In another type, the same effect is produced hydraulically through a piston and cam system.

It should now be noted that if blade angles are not adjustable,—a condition that attends fixed pitch operation,—a pro-

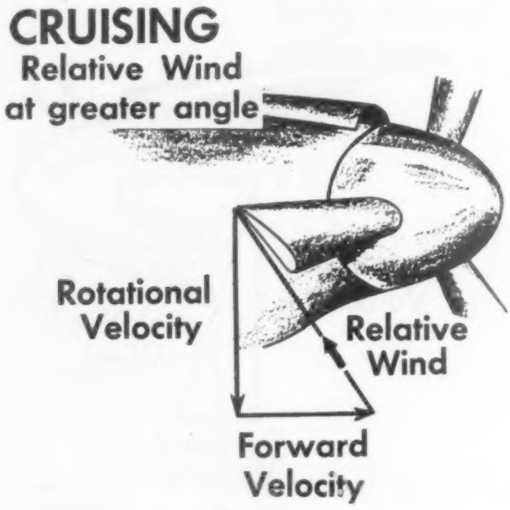


FIG. 9

peller and hence its engine over-speed during a descent and under-speed during a climb. Changes in direction of the relative wind, brought about by an increase or decrease in the force of the horizontal component, explain such off-speeds. During a descent, the increased force of the horizontal component causes a change in direction of the relative wind, bringing it into line with the plane of the blade, thereby cancelling out "bite" or air resistance and permitting the propeller to over-speed or "rev up." During an ascent, when the plane's speed is retarded, the converse is true. Diminution in force of the horizontal component causes the relative wind to alter its direction in a manner that offers greater resistance to the rotating blades. An underspeeding propeller and engine follow.

Under either condition, efficiency is sacrificed with the operation of the fixed pitch propeller because full engine power is not absorbed by a propeller running at off-speeds. With the pitch change propeller, these conditions are avoided. The blades, under influence of a governor, automatically rotate in their hub, altering their position in proportion to the changing angle of the relative wind. The "correct bite" into the air is maintained at all times, therefore, and the function of the pitch change propeller,—to maintain a constant engine speed and improve efficiency,—is fulfilled.

This description leads to a most interesting observation on flight performance: that the plane and its components not only act on the air but that the air, because of its resiliency, re-acts on the plane, thereby supporting the craft in gliding maneuvers and permitting a forward thrust by an engine driven propeller.

COMBINATION OF PROPELLER-DRIVE AND JET-PROPULSION FEATURES NEW NAVY FIGHTING PLANE

Something new in aircraft propulsion, a new Navy fighting plane equipped both with conventional propellers driven by a reciprocating engine and jet-push from an improved jet propulsion engine, was demonstrated before a group of scientists by the U. S. Navy, which also released many of the details of the plane and its power plants.

The two engines may be operated at the same time, to give maximum performance, or either may be operated alone. The unique power combination makes the plane equally efficient at high or low levels. It also combines the advantages of good cruising characteristics with high tactical performance.

The reciprocating engine, a Wright Cyclone radial power plant, is in the front of the plane, and the jet-propulsion engine, made by General Electric, is in the rear. This gives an even weight distribution that contributes to the plane's efficiency. The plane, already dubbed the "Fireball," is a low-winged, single-seat monoplane that at first glance appears to be a single-engine craft. Both engines are completely enclosed, and air scoops for the forward engine are within the engine cowling. The air intakes for the jet engine are in the leading edge of the wing near the fuselage, with the jet exhaust opening coming out under the tail.

This new plane is a product of the Ryan Aeronautical Company of San Diego, Calif., and when the war ended was beginning to roll off the production line. A Navy fighter squadron to be equipped with Fireballs was already in pre-combat training when the Japs surrendered. The Fireball never saw combat, but already the principles developed for its operation are being applied to a possible civilian version.

The General Electric-designed thermal jet engine in the Fireball is far more powerful than a conventional engine of the same weight; working alone, it can streak the plane along at approximately 300 miles an hour. The Wright Cyclone gives the craft a maximum range of 1,500 miles cruising at 207 miles an hour, and can develop a speed of 320 miles an hour. Operational features of the plane are good maneuverability, fast climbing, easy handling and speed.

PETS IN THE KINDERGARTEN

Viola M. Lynch
Parker Elementary Practice School, Chicago, Illinois

The problem of giving kindergarten children first hand experience with pets and animals discourages most teachers. There is no doubt that the care of pets adds a considerable amount of responsibility and work which many teachers feel is not worth the effort because of the heavy teaching load.

Now I am speaking for my own situation; that is, one teacher with an all-day session, two groups of children, no assistant, and at least thirty-five five year olds in each session.

The daily routine, the physical care of the room and equipment, not mentioning the socialization and habit training program, intellectual attainments, skills, and all that the kindergarten stands for, *alone* keeps one teacher as busy as she can be. Not much wonder that pets are given the "go-by." As with many other social subjects in other grades, vicarious experiences, stories, pictures and "talking-about" have to suffice for the average room.

From my own experience, having run the gamut of pets from goldfish and turtles to a live baby pig in the kindergarten, I feel that the experiences to be derived are so vital and worth while that no kindergarten year should be spent without having at least one live pet living with the children.

Just this fall, the first week of school, a lad named Simon, now ten years old, and whom I had had in the kindergarten five years ago, burst into the room one fine morning. His career had been checkered by the family's frequent moving, as city families have a way of doing. "I'm back again. Do you remember me? Have you still got the white rats? I went to the ——— school last year." Before I could get a word in edgewise he went on: "I remember this room and all the pets we had."

I started this year with pets. My plans hadn't called for any kind of animal the first week of school. My hands were full to the brim and running over with new and lively five-year-olds who, with the exception of a very few, had had no previous kindergarten or group experience. To my consternation, a college student appeared at my door—this first week of school, of all things!—holding a small box and a big bag of something. Would I like a family of white mice, mama and papa and six little offspring? I hesitated, then my wits returned. "But I

haven't a cage," I stammered. "I have," she said, "and here is five pounds of feed." I fell "like a ton of brick" and accepted the gift. Why not? Why wait? So as I write, the kindergarten now this first week of school has a family of mice plus four goldfish to start the year. I have no doubt I'll end the year with turtles, guinea pigs, and perhaps a hamster or two.

Last year another interesting experience occurred which would add another argument that pets do count. Another youthful visitor appeared. His school had a holiday so he came over to see some of his public school friends. His sister was in the kindergarten at the time. Danny had been in the kindergarten way back when, as well as his other brothers and sisters, each in turn.

Of course I couldn't say his name, but I remembered him well. After a few pleasantries he was left to browse and watch the children. Soon he began plying me with questions. Finally he said, "Haven't you any pets at all?" The tone implied a rebuke as well as great amazement. I admitted reluctantly that this particular year I had very few pets (this being spring). "I had some guinea pigs for a while, but in the new semester my load was great," I explained, "and pets add a lot of work." "Besides," I said, "my cages are worn out." And so it went on. "Not even a goldfish?" he chided. "Have you a bowl?" he asked. "Oh, yes," I replied. "Maybe I'll get it out some day." Then I was busy and forgot my visitor. Soon I realized he had gone. "So childlike," I thought, "no formalities of goodbye or thank you."

In about half an hour the door opened again and in walked my friend, beaming and holding a bucket which he thrust into my hands. "This is for you and the kindergarten." The children crowded around and we opened the bucket. In it were two goldfish. The goldfish bowl came out of hiding; the goldfish had a new home, and Danny had the satisfaction of knowing that the kindergarten would at least have some goldfish for pets.

A good cage is, of course, the first prerequisite to reduce the care of pets to a minimum. Having had makeshifts of all kinds, I can heartily endorse the acquisition of a good cage as the first requirement. It facilitates the handling of pets, makes them more comfortable, is a safety measure, helps eliminate odors, and establishes sanitary conditions necessary for the welfare of the children and the pets.

If the cage is easy to clean, and by that I mean eliminates

steps and takes just a few minutes to clean so that it can be done at least once a day, then it answers one of the requirements for a good cage. Even the children can help in the process. This gives them a feeling that the welfare and comfort of the animals is vital to their health. Keeping their house clean is important just as keeping the kindergarten rooms clean and neat is necessary.

The type and size of the cage depends on the kind of pet. I have found a rather large cage on a platform with rollers, so it can be moved about, to be the best type. Such a cage makes it possible for many children to sit or stand around it and have a full view of the pets. This is important, because the ego of the five-year-old demands *me first;* "I want to see." Pushing and crowding result, particularly when a new pet arrives. All want to see and should see. A minimum number of rules and regulations have to be made. This is another opportunity for the children to experience taking turns, giving elbow room, and sharing the enjoyment of watching the pets.

As the pet becomes an integral part of the room, the situations of pushing and crowding are eliminated because the children can watch for the times when "there is room around the cage." In fact, the pet corner never lacks for interested spectators. Much knowledge is gleaned from these casual opportunities to watch these animal friends.

Right at this point it may be well to answer another question. It is often argued that keeping animals and pets in school is cruel. Yes, it is, if they are not properly housed and cared for. Children should be taught kindness and a great regard for the animals' welfare. Here is a real chance to be kind, not just talk about it. Children should not be allowed to handle the pets carelessly or without supervision. I have seen them cruelly maul kittens or puppies who had no means of defense, while parents sat idly by watching the animal's attempt to evade its torturer.

Arguments are also advanced that animals in school are not sanitary. That, too, depends on the care the pets receive. Children should be taught to wash their hands after handling animals of any kind. Just telling them does not suffice. Having pets to handle and care for makes a real necessity for washing hands. It is a lesson well demonstrated and learned by actual doing.

Of course, the ideal situation would be a pet room or a fine outdoor pen or cage but very few public schools have such opportunities.

Having experimented with all manner of pets, I have found ring-necked doves win first place in my situation. Guinea pigs and rabbits are odoriferous and hard to keep clean. White rats are interesting and hardy, but messy and distasteful to some to care for. The long tail seems to bother many adults who feel a repugnance toward any rodent. The name "rat" itself stirs up animosities and prejudices not easily overcome.

White rats do present excellent opportunities for nature study and are appealing to children. However, rats sometimes bite, having temperaments akin to human beings. Some are gentle, some are cross. Letting children handle them does have its dangers. For all these reasons a pet requiring a small amount of care, which is adjustable to room situations, and doesn't bite, gives interesting opportunities to learn first hand nature's beautiful language, is a must for even a busy teacher.

The ring-necked dove satisfies these requirements for me. In fact, the male does not have to be removed from the cage when the young come, as is the case in many instances in animal life. Explaining that the father kills the young sometimes, or that even the mother destroys her young in some cases when disturbed, is a fact I do not care to discuss with little children. If it happens, then explain it, but rather avoid this calamity if possible.

In the case of the doves, both parents take care of the young. In fact, the children see that at a regular time each day the birds change places and the father, too, takes his turn sitting on the nest. He often talks to her as she sits on the eggs and brings her bits of food.

The birds are easy to keep clean and they soon adjust to the busy noises of the kindergarten. They can be left with safety and comfort over the week-end. Room temperature changes do not easily affect them; they are hardy birds. They do not bite, and there seem to be few requests to hold them.

Most children have had some experiences with cats and dogs. Birds they see but have little knowledge of them. Children know they fly but don't know one kind from another. They often talk about nests, eggs, and baby birds—sometimes because an adult talks to them about it—but more often it is just talk and not real knowledge about birds. This is no way for little children to learn. It must be a real experience in which they have identified themselves with the experience.

What a thrill it is to sit beside the cage and see the birds close

at hand. What fun to change the water and give the birds a fresh drink, or to put in feed; or bring bread crumbs or a hard boiled egg to supplement the daily diet. At first the children watch me clean the cage. Soon they offer to do this and that. The dove committees become one of the most coveted jobs of the week.

"Harry isn't here today. He should take care of the water for the doves. May I take his place today?" Molly was so enamored of the birds and so efficient that she could clean the cage as well as I.

The children enjoy hearing them coo. Whenever the birds "talked together" we always stopped what we were doing and listened. Soon the children discovered different calls which the birds gave. "He bows to her when he coos," was one observation. "The black ring goes nearly around his neck." "Why are they called ring-necked doves?" "Which is the mother?"

There are many concomitant learnings gleaned from these vital experiences. There is much opportunity for language expression and development. Poetry, singing, creative opportunities, stories—all are interwoven with this highly vital experience.

The children observed the mating process. They saw the billing and cooing. "Why, they kiss each other," said Johnny. Then came the great day. One egg was laid. We marked it on the calendar. It was Friday. On Monday the second egg was there. Then we watched and waited.

The school newspaper carried the news. Parents came to see the birds. We counted out eighteen to twenty-one days on the calendar and watched the birds take turns on the nest. Children would go one at a time and watch a while. They saw the father or mother turn over the eggs. It was an event to *see* the eggs. The parents kept them well hidden and didn't seem to resent the children standing close by.

All this time the cage could be conveniently cleaned and cared for without interfering with the birds.

And then the big day arrived. One egg hatched. The children took turns and finally all got to see the baby that day. "How little it is!" The baby was discovered because a child saw the broken egg shell on the floor of the cage. Great consternation arose over this discovery until it was explained that this was not a calamity but a real event. The egg had hatched and we had a baby bird. Seeing is believing, but even then some children couldn't really believe it. "Where did the baby bird come

from?" "From the egg, you dope," said one enthused observer. A nest and eggs and baby birds had a new meaning.

Then, of course, watching the baby birds fed was a never ending source of wonder. At first, cries of alarm, "The father is killing the baby," showed that they missed nothing. The birds were constantly under observation. Learning to fly was another interesting experience.

At first the babies were kept covered. Seeing them fed meant careful watching. Then the babies grew; their feathers grew. The whole cycle was a thrill. No attempt was made to put across scientific data. It was a joyous and worth while experience that was a part of everyday living and learning.

Was it worth while? The children who are now in the first grade greet me with, "Have you any doves in the kindergarten?" Even boys and girls who are in advanced grades in the school come in any chance they get to see what is going on in the kindergarten. Is there something there?

Animals and pets are a source of great joy and wonder to children. Why deprive them of these enriching experiences that are first hand when so much of their learning has to be from books? It is the teacher's job to provide interesting first hand experiences for her group. Some teachers have been successful with a hen and chicks, but I have felt it absolutely beyond my ability to handle such a problem adequately. It means various controls and week-end cooperation of a janitor, which isn't always available. Such situations often result in no profit and a big headache for the teacher. Why try an experiment like that at first? Take something which will be possible to handle with the maximum results.

I consider all efforts along this line to be amply rewarded by the gain in scientific knowledge and in character building.

QUICK-INTERCHANGEABLE CARGO SECTION FOR PLANES

An American of Japanese ancestry, Henry T. Nagamatsu of Cheektowaga, N. Y., has developed a principle of cargo-plane construction that promises greatly to speed the handling of air freight.

Instead of unloading and reloading through the conventional side door, which involves holding the plane idle for a long time, Mr. Nagamatsu provides a cargo-holding section that can be detached as a whole and lowered away from the plane on a pneumatic hoist. Waiting for it in a ramped pit below is a truck-trailer unit; the cargo section simply becomes the body of the truck. When this moves off, another truck, with similar cargo section already loaded, takes its place; the section is raised into place and secured, and the plane is ready for immediate flight.

AN ASTRONOMICAL HANDBOOK FOR THE SCIENCE TEACHER

ROBERT L. PRICE
*Joliet Township High School and Junior College,
Joliet, Illinois*

Between its covers, The Observer's Handbook, published annually by the Royal Astronomical Society of Canada, has a wealth of astronomical material for the science teacher. This handbook meets the requirements of authenticity, compactness and accessibility. Its use over a period of years has made it an invaluable aid in teaching, in laboratory work, and in observing.

Much general information ordinarily found in text books or encyclopedia is here presented in tabular form. Symbols and abbreviations, the Greek alphabet, constellation names and meanings, signs of the zodiac, and values of astronomical measurements and constants are summarized in the first pages of the book.

The familiar chart of data regarding the members of the solar system occupies one page and facts about the discovery, sizes and orbits of the twenty-eight satellites of the planets are found on the opposite page.

A table of data on the brightest stars gives their positions on the celestial sphere, apparent and absolute magnitudes, spectral types and parallaxes (from which their distances can be derived in more familiar units). In addition, data on radial velocity, motion in the line of sight, and proper motion, motion across the line of sight, are noted. The nineteen brightest stars which are the so-called first magnitude stars, are set in bold face type. The familiar names are not given but rather the designation by the Bayer system. For example. Alpha Leonis is used instead of Regulus.

The four seasonal star maps show only the outlines of the important constellations and can be used by the beginner who will follow the simple instructions which accompany them.

For the observation of the many interesting objects visible in a small instrument such as the refractors and reflectors used by amateurs, four lists are supplied. They deal with star clusters, galactic nebulae, extra-galactic nebulae and double and multiple stars. The Messier Catalogue numbers are given for the more familiar objects, photographs of which often appear

in astronomy and general science texts. The descriptive names, such as the Ring Nebula in Lyra for M57 of Messier's list, are noted for some of the galactic nebulae.

In recent issues of the handbook, the aerial navigation stars are enumerated with essential information and a key to pronunciation. The latter aids the student in his first venture with the many names of Arabic origin.

For the amateur interested in making observations of variable stars, charts of four important variables and a table of representative variables are supplied. Some instructions for making observations and for using the data obtained supplement the tables.

Most of the remaining information in the handbook is for the year of publication. It deals with phenomena such as the phases of the moon, the dates of which vary from month to month and from year to year.

The times of sunrise and sunset are given in tables for alternate days throughout the year in latitudes 36° to 52° by 4° intervals. The beginning of morning twilight and the ending of evening twilight are also given for several latitudes. Astronomical twilight, the time at which the center of the sun is 18° below the horizon is used. The duration of twilight in different latitudes can thus be determined fairly well by the use of these tables.

An ephemeris of the sun gives the sun's position on the celestial sphere for every third day of the year and the correction to the sundial, known as the equation of time, is included here. Five kinds of time are defined: apparent solar time, mean solar time, sidereal time (star time), standard time and daylight saving time. A map shows the standard time zones for most of North America.

The current calendar and the Julian Day Calendar with notations for its use, grace the inside front cover. Anniversaries and festivals listed refer to Dominion and religious holidays.

Daily times of moonrise and moonset for the year are now included and the phases are denoted in the margin. These times are also given for several latitudes. Calculations of lunar occultations of stars, visible at certain points in Canada, are made available for observers there.

The planets are discussed individually and their important configurations, such as conjunctions with the sun, greatest elongations, quadratures and oppositions, are given for the particular year of the handbook. The apparent motions of the

planets among the stars are shown on charts which make it possible not only to find a certain planet at a given time but to watch its motion relative to fixed stars. The magnitudes of the planets are given at opposition for those beyond the earth and at time of greatest brilliancy for the inner ones.

Eclipses for the year are outlined and, if visible in Canada, the circumstances of the eclipses are stated. The solar eclipse of July 9 is an example in the 1945 edition as is the lunar eclipse of December 19.

"The Sky Month by Month" gives observational data for the objects visible each month, their positions on the celestial sphere on the fifteenth day of the month, hours of transit, apparent magnitudes and whether the apparent motion is direct or retrograde.

Under "Astronomical Phenomena, Month by Month," phases of the moon, configurations of the planets and conjunctions of the planets with the moon are shown by means of symbols. Other phenomena noted are eclipses, meteor showers, perigee and apogee passages of the moon, perihelion and aphelion passages of the planets, stationary points in the apparent motions of the planets and other planetary phenomena.

Under this same heading, one finds the times of minima of the variable star, Algol, known as the "Demon's eye" because of its blinking. The positions of the four larger satellites of Jupiter are shown for every day in the year when Jupiter is visible. An "O" indicates the planet and numerals 1, 2, 3, and 4 show the positions of the satellites at a given hour.

An additional table gives the various phenomena of these satellites which are visible in a three or four-inch refractor or a small reflecting telescope. They include eclipses, occultations, transits of the satellites and transits of the satellite shadows.

To facilitate the use of some of the material, sample problems are solved. For the user's convenience, tables on mean temperatures and mean precipitation at several American cities are found on the inside of the back cover.

The low cost of the handbook when obtained in numbers over ten (twenty cents) makes it possible to supply each member of a class with it. For educational uses, no duty is required when the books enter the United States. The demand for the handbook necessitated extra printings this year. In ordering copies, a money order should be sent to the Secretary of the society at 198 College Street, Toronto. The year for which the handbook is desired should be stated.

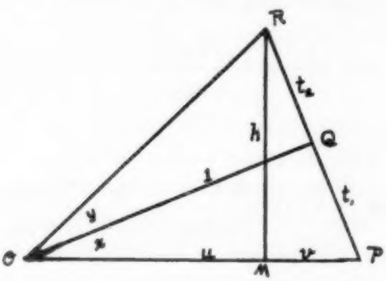
To use the monthly phenomena chart, the special "shorthand" expressing the various phenomena may need to be studied in a laboratory manual on astronomy. Astronomical texts will aid in a better understanding of the configurations. More complete star maps will be found in text books or observing manuals.

While several monthly magazines give astronomical events for each month and the government publications, the American Ephemeris and Nautical Almanac, give many pages of accurately computed positions, this handbook has the advantage of being easily carried, easily understood, and complete enough for all general uses. Its wide range of information has been outlined here so that science teachers who have been without such an aid may find it a useful tool in teaching astronomical units in general science or in the development of astronomical sidelines in physics or other science courses.

A DIRECT PROOF OF THE ADDITION FORMULA FOR TANGENTS

L. H. McFarlan
University of Washington, Seattle, Washington

The usual proof of the Addition Formula for the Tangent is based on a previous derivation of the corresponding formulas for Sines and Cosines. The following proof has the advantage of being independent of these formulas and follows directly from simple geometry and algebraic manipulations.



In the figure, the line OQ has the length 1 and the line PR is drawn perpendicular to OQ at Q. Obviously the line segments PQ and QR, of lengths t_1 and t_2 respectively, are the line repre-

sentations of Tan x and Tan y. The area of the triangle OPR can be expressed in two ways and the results equated. This gives

$$\frac{OQ\cdot PR}{2}=\frac{OP\cdot MR}{2}$$

or since $OQ=1$ and $PR=t_1+t_2$, one has

$$t_1+t_2=h(u+v), \tag{1}$$

where h, u, and v are the lengths of MR, OM and MP respectively. However $u+v=OP=\sqrt{1+t_1^2}$. Therefore

$$t_1+t_2=h\sqrt{1+t_1^2} \tag{2}$$

and consequently

$$h=\frac{t_1+t_2}{\sqrt{1+t_1^2}}\,. \tag{3}$$

Equation (1) may be rewritten in the form

$$\begin{aligned} t_1+t_2&=h^2\left(\frac{u}{h}+\frac{v}{h}\right)\\ &=h^2[\cot\,(x+y)+t_1] \end{aligned}$$

since $u/h=\cot(x+y)$ and $v/h=\tan\angle MRP=\tan x=t_1$. Now let one replace h in the above formula by its expression from (3). The result is

$$t_1+t_2=\frac{(t_1+t_2)^2}{1+t_1^2}\,[\cot\,(x+y)+t_1].$$

This may be solved for cot $(x+y)$ as follows:

$$\cot\,(x+y)=\frac{1+t_1^2}{t_1+t_2}-t_1=\frac{1-t_1t_2}{t_1+t_2}\,.$$

Therefore

$$\tan\,(x+y)=\frac{t_1+t_2}{1-t_1t_2}=\frac{\tan x+\tan y}{1-\tan x\tan y}\,.$$

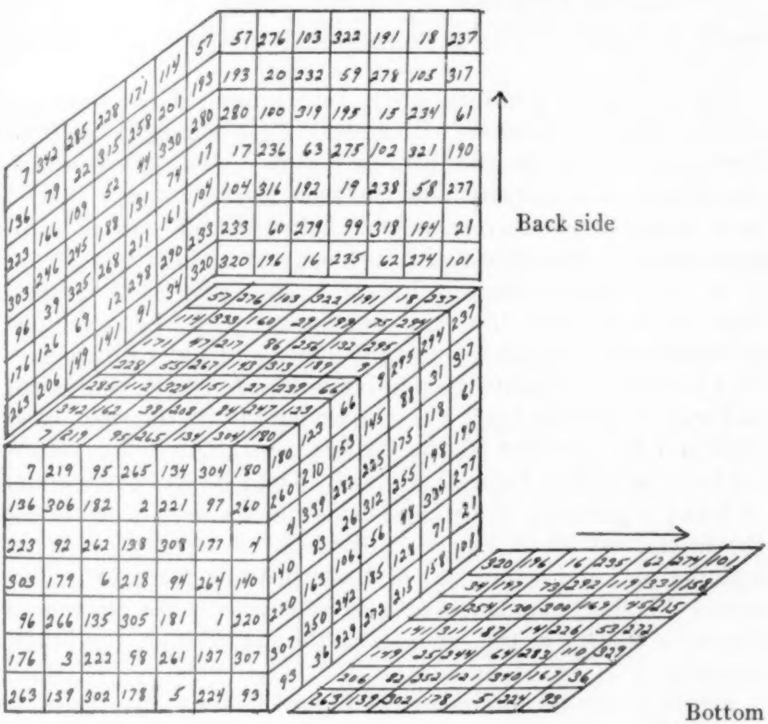
The Declaration of Independence is the grandest, the bravest and the profoundest political document that was ever signed by the representatives of the people.—*Ingersoll.*

MAGIC SQUARES AND CUBES

An analysis of their structures, methods of construction, and a complete set of figures for a $7 \times 7 \times 7$ magic cube.

WILLIAM E. BLOCK
Lake View High School,
Chicago, Illinois

FIG. $A'B'C'$
Exposed faces of a $7 \times 7 \times 7$ magic cube



The purpose of this article was to remove the magic from the magic squares. The slight of hand of the prestidigitators amuses those eager to follow the numerous operations involved in magic tricks. Likewise, "the sight of hands" of the present digitators confuses those eager to follow the numerical operations involved in magic squares. The sight of one's hands with their eight fingers and two offset thumbs has caused the adoption of a fixed notational, ordinal and cardinal number system to the base ten. This unquestioned number system puts the

magic in the magic squares by concealing the periodic arrangement of the numbers. The use of number systems to other bases reveals the basic structure and cyclic nature of the magic squares.

The writing of this article was originally undertaken to check on the constancy of summation in the article "Pandiagonal Magic Squares and Their Relatives" by Hiram B. Loomis, SCHOOL SCIENCE AND MATHEMATICS, December 1944. It is advisable to read that article simultaneously with this for an understanding of the first part of this article. Figures 1 to 13, found in Loomis' article, correspond respectively to Figures $1'$ to $13'$ here.

Figure $1'$ gives a natural order 5×5 square. These numbers are like ordinary numbers with the 6's, 7's, 8's, and 9's omitted. Corresponding to the numbers in Figure 1, they are consecutive numbers in a system to the base five. Figures $1'$ and 1 have a one-to-one correspondence between each pair of similarly placed terms. If one wishes to convert a number in Figure $1'$ to its correspondent in Figure 1, multiply the left hand digit by 5 and add the right hand digit to it. For example, to convert 34 of Figure $1'$, multiply 3 by 5 and add 4 which gives 19. Conversely, to convert a number in Figure 1 to its equivalent in Figure $1'$, divide by 5. The remainder will be the right hand digit and the quotient will be the left hand digit. For example, (a) to convert 19 of Figure 1, divide by 5 which gives a remainder of 4 and a quotient of 3 which, using place value, becomes 34; (b) to convert 20 of Figure 1, divide by 5 which gives a remainder of 5 and a quotient of 3 which, using place value, becomes 35. The avoidance of a zero in the units column of Figure $1'$ assists in the removal of the magic from the magic squares.

Figure $2'$ can be obtained from Figure $1'$ in exactly the same way as Figure 2 is obtained from Figure 1. Figure $2'$ can be transformed into Figure 2 term by term as explained and illustrated in the preceding paragraph. Note that 19 in Figure 2 occupies the same spaces as 34 in Figure $2'$ and, conversely, 35 in Figure $2'$ occupies the same space as 20 in Figure 2. The sum indicated in Figure $2'$ is the amount when the numbers in Figure $2'$ are converted from the base 5 to the base 10.

Figures $3'$ and $4'$ can be obtained from Figure $1'$ in exactly the same way Figures 3 and 4 are obtained from Figure 1. Figures 3 and 4 can be transformed into Figures $3'$ and $4'$, respec-

tively, term by term as explained previously. Note that 19 in Figures 3 and 4 occupy the same spaces as 34 in Figures 3′ and 4′

FIG. 1′

0 1	0 2	0 3	0 4	0 5	0 1	0 2	0 3	0 4	0 5
1 1	1 2	1 3	1 4	1 5	1 1	1 2	1 3	1 4	1 5
2 1	2 2	2 3	2 4	2 5	2 1	2 2	2 3	2 4	2 5
3 1	3 2	3 3	3 4	3 5	3 1	3 2	3 3	3 4	3 5
4 1	4 2	4 3	4 4	4 5	4 1	4 2	4 3	4 4	4 5

FIG. 2′

0 1	1 2	2 3	3 4	4 5
0 2	1 3	2 4	3 5	4 1
0 3	1 4	2 5	3 1	4 2
0 4	1 5	2 1	3 2	4 3
0 5	1 1	2 2	3 3	4 4

sum = $(0+1+2+3+4)5+(1+2+3+4+5)$
or
65

FIG. 3′

0 1	1 3	2 5	3 2	4 4
0 2	1 4	2 1	3 3	4 5
0 3	1 5	2 2	3 4	4 1
0 4	1 1	2 3	3 5	4 2
0 5	1 2	2 4	3 1	4 3

and

FIG. 4′

0 1	1 4	2 2	3 5	4 3
0 2	1 5	2 3	3 1	4 4
0 3	1 1	2 4	3 2	4 5
0 4	1 2	2 5	3 3	4 1
0 5	1 3	2 1	3 4	4 2

sum = 65

FIG. 5′

0 1				
			1 1	
	2 1			
				3 1
		4 1		

FIG. 6′

0 1				
		0 2	1 1	
	2 1			0 3
	0 4			3 1
		4 1	0 5	

FIG. 7′

0 1	1 5	2 4	3 3	4 2
3 4	4 3	0 2	1 1	2 5
1 2	2 1	3 5	4 4	0 3
4 5	0 4	1 3	2 2	3 1
2 3	3 2	4 1	0 5	1 4

FIG. 8′

0 1				
1 1	0 2			
2 1	1 2	0 3	4 4	3 5
3 1	2 2	1 3	0 4	4 5
4 1	3 2	2 3	1 4	0 5
0 1	4 2	3 3	2 4	1 5
1 1	0 2	4 3	3 4	2 5
			4 4	3 5
				4 5

FIG. 9′

2 1	1 2	0 3	4 4	3 5	2 1	1 2		
	3 1	2 2	1 3	0 4	4 5	3 1		
		4 1	3 2	2 3	1 4	0 5		
		1 5	0 1	4 2	3 3	2 4	1 5	
		3 4	2 5	1 1	0 2	4 3	3 4	2 5

FIG. 10′

3 5	2 1	1 2	0 3	4 4
1 3	0 4	4 5	3 1	2 2
4 1	3 2	2 3	1 4	0 5
2 4	1 5	0 1	4 2	3 3
0 2	4 3	3 4	2 5	1 1

FIG. 11′

1 2	0 3	4 4	3 5	2 1
0 4	4 5	3 1	2 2	1 3
4 1	3 2	2 3	1 4	0 5
3 3	2 4	1 5	0 1	4 2
2 5	1 1	0 2	4 3	3 4

FIG. 12′

2 1				0 3
	2 2		1 3	
		2 3		
	3 3		2 4	
4 3				2 5

FIG. 13′

2 1	4 4	1 2	3 5	0 3
0 4	2 2	4 5	1 3	3 1
3 2	0 5	2 3	4 1	1 4
1 5	3 3	0 1	2 4	4 2
4 3	1 1	3 4	0 2	2 5

respectively; conversely, 35 in Figures 3′ and 4′ occupy the same spaces as 20 in Figures 3 and 4 respectively.

From the cyclic arrangement of the units digits in Figures 2′, 3′, and 4′ constancy of summation occurs when the base and the common difference of the units digit are relatively prime. The arithmetic progression of the terms leads to the theorem that

the sum is

$$\frac{N}{2}(N^2+1) \text{ for an } N\times N \text{ square.}$$

Figures 5′ through 13′ can be obtained from Figure 1′ in exactly the same way Figures 5 through 13 are obtained from Figure 1. Figures 5 thr ugh 13 can be transfromed into Figures 5′ through 13′ term by term as explained previously. Note that 19 in Figures 5 through 13 occupies the same spaces as 34 in Figures 5′ through 13′ respectively; conversely 35 in Figures 5′ through 13′ occupies the same spaces as 20 in Figures 5 through 13, respectively.

Figures equivalent to Figures 7, 10, 11 and 13 can be made instead by the following preferred procedure:

1.1 Beginning with any number from 0 to 4 write a cyclic sequence wherein the successive terms have a difference of

A. one, thus: 0, 1, 2, 3, 4, 0, 1, 2, 3, · · ·
B. two, thus: 0, 2, 4, 1, 3, 0, 2, 4, 1, · · ·
C. three, thus: 0, 3, 1, 4, 2, 0, 3, 1, 4, · · ·
D. four, thus: 0, 4, 3, 2, 1, 0, 4, 3, 2, · · ·

2.1 In a 5×5 square enter any sequence beginning with any term in any row or column.

2.2 In successive rows or columns, cyclicly enter the selected sequence of step 2.1 in any second or the same cyclic order. (Figures A_1, B_1 and C_1 illustrate step 2 for three 7×7 squares.)

3.1 and 3.2. Avoiding duplications, do the same as step 2 for a second 5×5 square.

4.1 Superimpose these squares entering terms of one square to the left and the terms of the other to the right in each box.

4.2 Change the 0's of the right hand entries to 5's.

5.1 The square of step 4 is a magic square where the number couples are considered as belonging to a number system to the base five. For each box of the square of step 4, multiply the left hand digit by 5, add the right hand digit and insert the resultant number in its corresponding box of a final blank 5×5 square.

The resulting figure is a magic square.

Figure 7′ has sequence A for left hand rows.

Figure 7′ has sequence C for left hand columns.
Figure 7′ has sequence D for right hand rows.
Figure 7′ has sequence C for right hand columns.
Figure 7′ is equivalent to Figure 7.

Figure 10′ has sequence D for left hand rows.
Figure 10′ has sequence C for left hand columns.
Figure 10′ has sequence A for right hand rows.
Figure 10′ has sequence C for right hand columns.
Figure 10′ is equivalent to Figure 10.

Figure 11′ has sequence D for left hand rows.
Figure 11′ has sequence D for left hand columns.
Figure 11′ has sequence A for right hand rows.
Figure 11′ has sequence B for right hand columns.
Figure 11′ is equivalent to Figure 11.

Figure 13′ has sequence B for left hand rows.
Figure 13′ has sequence C for left hand columns.
Figure 13′ has sequence C for right hand rows.
Figure 13′ has sequence C for right hand columns.
Figure 13′ is equivalent to Figure 13.

The above procedure for making magic squares can be applied to cases where the size of the square and the cyclic sequence difference are relatively prime.

The above procedure for making magic squares can be extended to the construction of n dimensional figures. The details for the construction of Figure $A'B'C'$ illustrating the process for a $7\times7\times7$ cube follow:

Figure A_1 has a cyclic sequence difference of 2 in each row.
Figure A_1 has a cyclic sequence difference of 1 in each column.
Figure B_1 has a cyclic sequence difference of 3 in each row.
Figure B_1 has a cyclic sequence difference of 1 in each column.
Figure C_1 has a cyclic sequence difference of 4 in each row.
Figure C_1 has a cyclic sequence difference of 1 in each column.
Figure $A_1B_1C_1$ consists of the combination of Figure A_1 in the units column, Figure B_1 in the 7's column and Figure C_1 in the 49's column.
Figure $A_2B_2C_2$ is derived from Figure $A_1B_1C_1$ by cyclicly increasing each term in the units place by 2, by increasing each term in the 7's place by 5, and by increasing each term in the 49's place by 3.
Figure $A_3B_3C_3$ to Figure $A_7B_7C_7$ are derived in order by

maintaining the cyclic difference determined in obtaining Figure $A_2B_2C_2$ from Figure $A_1B_1C_1$.

Figure $A_1B_1C_1$ to Figure $A_7B_7C_7$ represent magic squares

FIG. A_1

1	3	5	7	2	4	6
2	4	6	1	3	5	7
3	5	7	2	4	6	1
4	6	1	3	5	7	2
5	7	2	4	6	1	3
6	1	3	5	7	2	4
7	2	4	6	1	3	5

FIG. B_1

1	4	0	3	6	2	5
2	5	1	4	0	3	6
3	6	2	5	1	4	0
4	0	3	6	2	5	1
5	1	4	0	3	6	2
6	2	5	1	4	0	3
0	3	6	2	5	1	4

FIG. C_1

1	5	2	6	3	0	4
2	6	3	0	4	1	5
3	0	4	1	5	2	6
4	1	5	2	6	3	0
5	2	6	3	0	4	1
6	3	0	4	1	5	2
0	4	1	5	2	6	3

where the number triples are considered as belonging to a number system to the base seven. For each box of each square, multiply the left hand digit by 49, the middle digit by 7, and add these two products to the right hand digit;

FIG. $A_1B_1C_1$

111	543	205	637	362	024	456
222	654	316	041	403	135	567
333	065	427	152	514	246	601
444	106	531	263	625	357	012
555	217	642	304	036	461	123
666	321	053	415	147	502	234
007	432	164	526	251	613	345

FIG. $A_2B_2C_2$

364	026	451	113	545	207	632
405	137	562	224	656	311	043
516	241	603	335	067	422	154
627	352	014	446	101	533	265
031	463	125	557	212	644	306
142	504	236	661	323	055	417
253	615	347	002	434	166	521

FIG. $A_3B_3C_3$

547	202	634	366	021	453	115
651	313	045	407	132	564	226
062	424	156	511	243	605	337
103	535	267	622	354	016	441
214	646	301	033	465	127	552
325	057	412	144	506	231	663
436	161	523	255	617	342	004

insert the resultant sum in its corresponding box in one of seven blank 7×7 squares. Figure $A_1'B_1'C_1'$ to Figure $A_7'B_7'C_7'$ are obtained in this manner from Figure $A_1B_1C_1$ to Figure $A_7B_7C_7$, respectively.

FIG. $A_4B_4C_4$

023	455	117	542	204	636	361
134	566	221	653	315	047	402
245	607	332	064	426	151	513
356	011	443	105	537	262	624
467	122	554	216	641	303	035
501	233	665	327	052	414	146
612	344	006	431	163	525	257

FIG. $A_5B_5C_5$

206	631	363	025	457	112	544
317	042	404	136	561	223	655
421	153	515	247	602	334	066
532	264	626	351	013	445	107
643	305	037	462	124	556	211
054	416	141	503	235	667	322
165	527	252	614	346	001	433

FIG. $A_6B_6C_6$

452	114	546	201	633	365	027
563	225	657	312	044	406	131
604	336	061	423	155	517	242
015	447	102	534	266	621	353
126	551	213	645	307	032	464
237	662	324	056	411	143	505
341	003	435	167	522	254	616

Figure $A_1'B_1'C_1'$ to Figure $A_7'B_7'C_7'$ collectively form Figure $A'B'C'$ which is the desired magic cube.

The numbers 1, 2, 3, $\cdots$, 343 are used once and only once.

FIG. $A_7B_7C_7$

635	367	022	454	116	541	203
046	401	133	565	227	652	314
157	512	244	606	331	063	425
261	623	355	017	442	104	536
302	034	466	121	553	215	647
413	145	507	232	664	326	051
524	256	611	343	005	437	162

FIG. $A_1'B_1'C_1'$

57	276	103	322	191	18	237
114	333	160	29	199	75	294
171	47	217	86	256	132	295
228	55	267	143	313	189	9
285	112	324	151	27	239	66
342	162	38	208	84	247	123
7	219	95	265	134	304	180

FIG. $A_2'B_2'C_2'$

193	20	232	59	278	105	317
201	77	289	116	335	155	31
258	127	297	173	49	212	88
315	184	11	230	50	269	145
22	241	68	287	107	326	153
79	249	125	337	164	40	210
136	306	182	2	221	97	260

Each of the seven squares is pandiagonal with a sum of 1204. Each face of the cube is pandiagonal with the same sum of 1204. Each right section of the cube is pandiagonal with the sum of

Fig. $A_3'B_3'C_3'$

280	100	319	195	15	234	61
330	157	33	203	72	291	118
44	214	90	253	129	299	175
52	271	147	310	186	13	225
109	328	148	24	243	70	282
166	42	205	81	251	120	339
223	92	262	138	308	177	4

Fig. $A_4'B_4'C_4'$

17	236	63	275	102	321	190
74	293	113	332	159	35	198
131	301	170	46	216	85	255
188	8	227	54	273	142	312
245	65	284	111	323	150	26
246	122	341	168	37	207	83
303	179	6	218	94	264	140

Fig. $A_5'B_5'C_5'$

104	316	192	19	238	58	277
161	30	200	76	288	115	334
211	87	257	133	296	172	48
268	144	314	183	10	229	56
325	152	28	240	67	286	106
39	209	78	248	124	343	163
96	266	135	305	181	1	220

1204. Each diagonal section is semi-pandiagonal. Many other properties reveal themselves in an analysis of Figure $A_1B_1C_1$ to Figure $A_7B_7C_7$ such as: The sum where N is the number of terms to an edge and m is the dimension of the figure is $N/2(N^m+1)$.

FIG. $A_6'B_6'C_6'$

233	60	279	99	318	194	21
290	117	336	156	32	202	71
298	174	43	213	89	259	128
12	231	51	270	146	309	185
69	281	108	327	154	23	242
126	338	165	41	204	80	250
176	3	222	98	261	137	307

FIG. $A_7'B_7'C_7'$

320	196	16	235	62	274	101
34	197	73	292	119	331	158
91	254	130	300	169	45	215
141	311	187	14	226	53	272
149	25	244	64	283	110	329
206	82	252	121	340	167	36
263	139	302	178	5	224	93

The purpose of this article has become an exposition of the use of number systems to bases other than 10. In an earlier article "The 'Duomal' System of Numeration and Computation," SCHOOL SCIENCE AND MATHEMATICS, October 1936, I presented some of the valuable properties of a combined binary-octonary number system and urged the universal adoption of the same. If it were necessary to have but one number system I would still be of the same opinion. However, as shown in this article, it is often desirable to use number systems to many bases for a clearer understanding of a problem.

TOLERANCE IN SCIENCE

AARON GOFF

Cleveland Junior High School, Newark, New Jersey

SCENE I

Introduction—spoken by a student.

Scientists are human beings and think the way most of you think. They make their discoveries in many different ways and for many different reasons. Today, the science department is going to show how some very important discoveries and inventions were produced in the past.

Among the most important requirements for such work always have been keen observation, courage, keen thinking and a questioning mind. One of the greatest minds of all times was that of Galileo, the Italian scientist who lived when the Puritans were being driven out of England and when the Pilgrims came to America.

Let us imagine ourselves back in the year 1586, when Galileo was 22 years old. He is explaining some new-fangled idea to one of his friends.

Two actors examine pendula.

FRIEND. What kind of contraptions are these?

GALILEO. It all started in church last Sunday. I was watching that chandelier as I prayed, and its movement was most regular. I was sure that each swing took the same length of time, whether it was a wide or narrow one.

FRIEND. How did this chandelier start swinging?

GALILEO. The sexton brushed against it when he lit the candles. I was entranced and I am afraid I forgot all about my prayers. But I had no way of proving my theory that the time of swinging depends only on the length of the pendulum and not on the width of the swing.

FRIEND. What did you call that thing? I thought you were talking about a chandelier.

GALILEO. Excuse me for getting ahead of the story, but I have set up experiments like these, with weights suspended by strings and I am calling them pendula, from the Latin word for hanging weights. I have been able to prove that the longer the string is, the longer it takes to swing. Also, these experiments prove that the width of the swing does not affect the time it takes. I measure the time by my heartbeats.

FRIEND. But why experiment? I'm sure Aristotle must have written about such things two thousand years ago. All the answers are found in his books. That's why no-one ever thinks of this fooling around that you call experimenting.

GALILEO. That's the trouble. No one thinks of experimenting or of doing anything original. Philosophers have been in a rut for two thousand years and its about time we had a New Deal. I, personally, have found several mistakes and omissions in Aristotle's works.

FRIEND. I can't believe it. You're either lying or mad.

GALILEO. I can easily prove to you that I'm right. Now look here. Notice that one of these strings is four times as long as the other. The longer one, you see, takes longer to make one complete swing. Let's count the swings and we'll be able to see how they compare. You count the swings of the long one, and I'll count the swings of the short one. Let's go! 1, 2, 3, 4, 5 etc. (*One pendulum may be made four times as long as the other.*) I want you to know that nowhere in Aristotle's works is there even a mention of this wonderful idea.

FRIEND. I don't see anything wonderful about it.

GALILEO. Some day there will be clocks which will be kept accurate by a pendulum. It is the most regular way of measuring small intervals of time I have ever seen. By the way I can prove your friend Aristotle wrong on another score.

FRIEND. Go ahead, let's see your brainstorm.

GALILEO. If you will accompany me to yonder Leaning Tower, I shall prove to you that heavy and light objects of the same size, such as this iron ball, and this piece of wood, will fall together, and strike the ground at the same time.

FRIEND. I won't believe it if I see it. It's against common sense and everything that has ever been written. You must have a trick up your sleeve, but I'll come along just for the devil of it.

Objects may be dropped from balcony of auditorium or any other high spot.

GALILEO. They both struck at the same instant. So, you see, it is only by experimenting that the truth may be found.

Scene II

Introduction by student

So, the keen, inquiring mind of Galileo overcame the laziness which had taken possession of human minds for hundreds of

years. His observations and experiments helped open up the Scientific Age in which facts are found by doing and trying, not in books thousands of years old. Since his time hundreds of discoveries have been made by men and women who studied the facts, experimented and won out. The opposition to new ideas which we heard Galileo's friend express, was not new. Nor has such stubbornness ceased to exist. It is interesting to know that many doctors and politicians fought the use of ether to deaden pain because they said, "Man was made to suffer."

About 75 years ago another great scientist was having trouble convincing the doctors of France that some diseases are caused by bacteria. Of course, Louis Pasteur had scientific proof of his beliefs. But the doctors were stubborn and hated to be proved wrong. They found all sorts of excuses to laugh at Pasteur's findings. Let us listen to a discussion at a meeting of the Academy of Medicine in the year 1869 in Paris.

CHAIRMAN. Gentlemen, I am indeed very sorry to inflict upon you so ridiculous a story as that proposed by this man Pasteur. In the first place, he is not even a physician. He is only a doctor of chemistry. We should not even have to hear him were it not for the *insistence* of Dr. Chalembeau, who is a member of this organization. As you know, this charlatan, Pasteur, claims that people get sick because tiny, little bacteria get into their bodies and attack their tissues and give off poisons. Imagine that—invisible little things that can be seen only through a microscope. How can they harm a person who is ten billion times as large?

1ST DOCTOR. I have never heard of these things called bacteria. It seems to me that the College of Physicians and Surgeons would have taught us something about them if they are that bad. It sounds like nonsense to me.

2ND DOCTOR. I remember studying about bacteria for a month or so in the University of Lyons, but all that we knew was that they cause decay of food and dead bodies. We were taught that they cannot attack the living body because of the vital force within it. I won't believe it till I see it proved.

3D DOCTOR. I don't see why we have to waste our time listening to a chemist. Let him stick to his vials and retorts while we take care of the human body. It's a waste of time, if you ask me.

CHAIRMAN. Dr. Chalembeau, will you please explain why you are so anxious for us to hear Pasteur?

DR. CHALEMBEAU. I was very skeptical about Dr. Pasteur's ideas until I visited England last year. In England, all of the surgeons are following the advice of Dr. Lister in using cleanliness as part of their operating technique. They spray the air with carbolic acid, wash their hands and instruments carefully before an operation, and most important of all, actually clean up their instruments between patients. (*Other doctors laugh.*) Yes, and now only 10% of their surgical cases die while 50% of ours are still passing away because of blood poisoning after an operation. I am convinced that Pasteur is on the right track when he blames these diseases on bacteria. Cleanliness will eliminate the bacteria and prevent sickness. May I introduce Dr. Louis Pasteur?

CHAIRMAN. Let him enter. (*Pasteur enters with microscope*). Dr. Pasteur, we shall listen to you for no more than five minutes, we are very busy men.

PASTEUR. I am most humble before this illustrious group of France's foremost physicians. The facts which I shall present will speak for themselves. My labors in this field began in 1861 when I was called upon by the wine makers of south France to find out why their wines were turning sour. You may know that I discovered the cause to be bacteria. I had learned to use the microscope in my study of the chemistry of crystal structure and therefore applied that instrument to every problem.

Then, you may remember that the silk worm industry was almost wiped out before I found the cause of their disease. Again, it was a matter of strange bacteria, this time causing the death of an organism. And again, as with the wine industry, cleanliness and sterilization wiped out the danger.

I began to realize that perhaps other animals and human beings might be affected by these microscopic bacteria and directed my researches to test that theory. At last I have the proof for which I have been seeking.

These pigeons (rats, or mice or rabbits) have helped me prove that tiny bacteria are the cause of at least one disease, cholera. (*Physicians look over animals*). Two weeks ago, I injected blood from a cholera patient into this pigeon. If any of you gentlemen should like to see the tiny organisms which are always found in the bodies of cholera victims you may see them moving around under this microscope. (*Two of the physicians look into the microscope and move away, shaking*

their heads skeptically.) These bacteria are never found in the bodies of healthy persons nor in the bodies of those who die for other reasons. But this bird is now sick, with all of the symptoms which you can recognize.

FIRST PHYSICIAN. But how do you know that you gave the disease to this pigeon by your injections? Could it not be the food, or the air, or the water or the light or even the heat?

SECOND PHYSICIAN. Or the devil?

PASTEUR. I have thought of that and have kept with this sick bird a sister pigeon, hatched at the same time. This healthy bird was kept in the same room, on the same shelf, and given exactly the same food as this sick one. The only difference between the two birds, and I repeat—*the only difference*—is that one had the injection of bacteria while the other did not. Scientifically, the problem is solved. I feel that we now know that cholera is caused by bacteria.

2ND PHYSICIAN. Doctor, you have something there.

3RD PHYSICIAN. Why not experiment further—with other animals.

1ST PHYSICIAN. Yes, that's good. I think that we should examine too, the bodies of human victims.

DR. CHALEMBEAU. I am sure that after all this is done you will be thoroughly convinced.

CHAIRMAN. Dr. Pasteur, the Academy of Medicine directs you to carry on further experiments on cholera. We feel that your findings so far justify some recognition from us.

Scene III

Introduction by student.

We have seen how science has had to struggle against backward thinking and against professional vanity. In many countries and in various times, science has had to overcome the most vicious and damnable of all obstacles—racial prejudice. You all know of the way the Nazis eliminated Jewish and Polish scientists so brutally within the past ten years. In our country, the Negro scientist has been the one who had to struggle so long to receive recognition and assistance. The greatest of these was George Washington Carver, whose name may some day rank with Thomas A. Edison as an inventor and benefactor of civilization. Edison and Henry Ford both thought well enough of Carver to work with him on many projects.

In 1921, Carver was still comparatively unknown in this country although the British Academy of Sciences had honored him by membership in 1916. This humble man was then working on several processes which he hoped would bring to people of the south some of the benefits of modern civilization. Let us witness a scene in Carver's laboratory, which was to lead to his recognition in this country.

(Stage setting). Carver, surrounded by laboratory equipment, flasks, burners, test tubes, bottles, jars, peanuts, sweet potatoes, soil, etc. Bell rings, assistant walks in.

ASSISTANT. Two gentlemen to see you, Dr. Carver. They look rather important. Maybe they are those men who wanted you to come to Washington.

CARVER. I think I did receive a telegram from them yesterday. Let them come in. I'll be with them as soon as I finish this titration. (*He drips acid from burette into colored indicator until color disappears, as two Senators enter and look on curiously and with astonishment.*) Good afternoon, I'll be through in a minute.

1ST SENATOR. We can wait. This is a very well equipped laboratory that you have here.

CARVER. It took us a long time to gather this equipment and much of it is improvised. You know we have great difficulty in financing our work here.

2ND SENATOR. We may be able to do something for you on that score if you can prove the value of your work. Tell me, Mr.—er—Dr. Carver, how did you become interested in peanuts and sweet potatoes?

CARVER. Ever since my childhood, when I was a slave, the unhappiness of my people has been my deepest sorrow. I have devoted my life since college to improving their conditions in whatever way I could. When the market for cotton in the world disappeared, and the boll weevil attacked our crops, the whole south suffered and I knew that we had to plant other crops. The South must no longer be a "one crop" region. My research showed that peanuts and sweet potatoes grew exceptionally well in these sections.

1ST SENATOR. That's very interesting, but what can all of these peanuts and potatoes be used for? People don't eat much of these foods, and they aren't any good for anything else. It will just be another case of over production and a glut on the market, like cotton.

CARVER. To answer your question is one of the principal purposes of a research laboratory. First, we took the peanut apart, chemically speaking. When we knew what was in the peanut we were able to reorganize it, change it and separate its parts. To date, we have been able to produce in this laboratory, and a few of these things are being produced commercially, all of those items which you see in those jars.

Senators inspect jars and read labels in voices expressing amazement.

"This looks like corn flakes, it's marked 'breakfast food'."

"Ice cream powder, just add water and freeze."

"Dyes," "A substitute for quinine."

"Cattle feed," "Milk," "Coffee substitute."

"Salad oil," "Linseed oil substitute."

"Face Powder," "Shampoo," "Soap," "Plastics."

1ST SENATOR. This is miraculous. The entire south will be saved if we can encourage the planting of peanuts in addition to cotton.

CARVER. Don't forget the sweet potato. I have been able to produce 107 useful things from them. Not only flour, but syrups, cocoanut substitutes, stains, and cattle food. Gentlemen, the soil of the south is its chief asset. We have even used its clay to produce paints and stains.

2ND SENATOR. This has been one of the most educational afternoons in my life. We shall take your story back to Congress and do everything possible to help you save the South and your people.

1ST SENATOR. Will you be able to present your case for the peanut before the Senate if we can arrange a date? I believe that your work is of the greatest value to the whole nation and they must learn about it from *you*. It has been a privilege to spend this hour with you, Professor Carver.

Senators shake hands with Doctor Carver and walk off stage.

EPILOGUE

Do you know that at one time people believed:

That riding in trains was considered a cause of brain disease?

That the steam engine was a toy?

That Edison and Alexander G. Bell were queer?

That the telephone would make people deaf?

That X-rays were invented by the devil?

That typing would ruin women's health?

That the airplane could never be successful?

New ideas have always met opposition because of selfishness, jealousy, and the difficulty of changing peoples' minds. Let us hope that our representatives at the great peace meetings and their associates from other nations will have less trouble in overcoming their obstacles than did Galileo, Pasteur, and Carver. Truth, based on facts, must win out.

FILLING A SQUARE WITH CIRCLES

ARTHUR PORGES
2743 W. San Marino St., Los Angeles 6, California

The problem discussed here resulted from the curiosity of an idle moment concerning what proportion of the area of a given square can be "filled" with circles, and the solution seemed interesting enough to encourage the belief that it might interest others.

Specifically, the problem is that of determining what part of the total area of a square of side S can be "filled" with P circles of five distinct "classes" as the radii of the circles decrease without limit and, consequently, P approaches infinity.

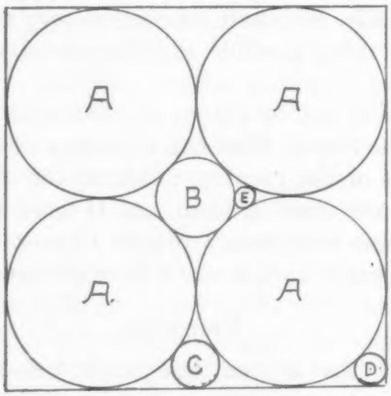


FIG. 1

Figure 1, following, for the case $P=17$, is adequate to exhibit the five classes of circles considered.

Circles "A," the primary "space-fillers," compose a class, each

member of which is tangent to two concurrent sides of the square and two other Class "A" circles, a side of the square and three other Class "A" circles, or four other Class "A" circles.

Circles "B" form a class of which each member is tangent to four Class "A" circles.

Circles "C" comprise the third class, each member of which is tangent to a side of the square and two Class "A" circles.

Circles "D," of which there are always only four, form the class of "corner" circles, each member of which is tangent to two concurrent sides of the square and a Class "A" circle.

Circles "E," the last considered, compose a class of which each member is tangent to two Class "A" circles and one Class "B" circle.

To generalize the problem for any number, P, of circles, we let the number of Class "A" circles equal N^2, whence the number of members composing each of the other four classes is readily found to be:

$$\begin{aligned} &\text{Class "B":} && (N-1)^2. \\ &\text{Class "C":} && 4(N-1). \\ &\text{Class "D":} && 4. \\ &\text{Class "E":} && 4(N-1)^2. \end{aligned} \tag{1}$$

At this point the reader might pause and venture a guess as to the relative amount of space filled by each class of circles as P approaches infinity.

Since the radius, R, of each Class "A" circle, of which there are N^2, is obviously

$$R=\frac{S}{2N}, \tag{2}$$

where S is a side of the given square, we can readily determine the radius of each of the other four classes of circles by referring to Figure 2.

If, in Figure 2, we let X equal the radius of a Class "B" circle, we have

$$(R+X)^2=R^2+R^2, \tag{3}$$

whence

$$X=R(\sqrt{2}-1). \tag{4}$$

For the Class "C" circle of radius Y, our equation becomes

$$(R+Y)^2=R^2+(R-Y)^2, \tag{5}$$

from which we find

$$Y=\frac{R}{4}. \tag{6}$$

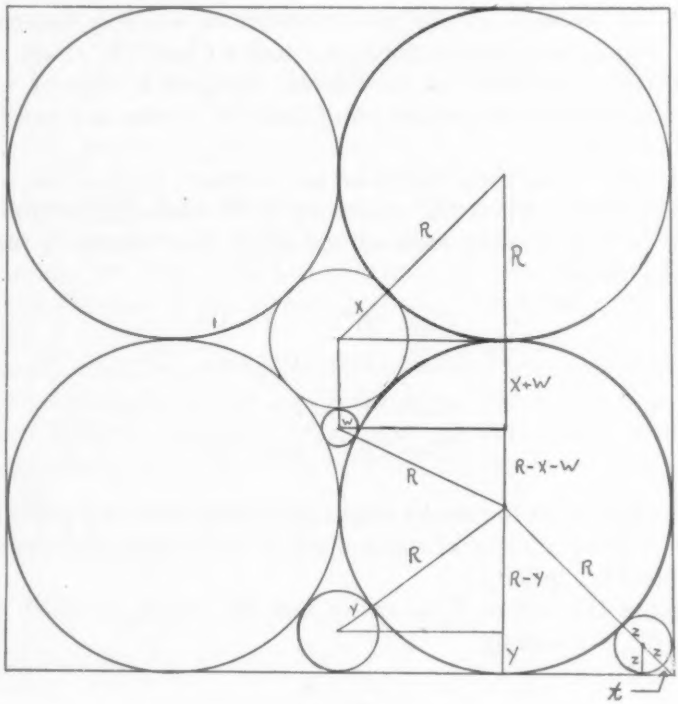


FIG. 2

To determine the radius, Z, of a Class "D" circle, we use

$$\sin 45° = \frac{R}{R+2Z+t}, \qquad \sin 45° = \frac{Z}{Z+t}, \tag{7}$$

whence, on eliminating the auxiliary variable t, we find

$$Z=R(3-2\sqrt{2}). \tag{8}$$

It now remains to find W, the radius of a Class "E" circle. Here the equation is

$$(9) \qquad (R+W)^2=R^2+(R-X-W)^2,$$

from which we find

$$(10) \qquad W=\frac{(R-X)^2}{2(2R-X)}=\frac{R}{7}(5-3\sqrt{2}).$$

We are now in a position to set up the expression K for the combined areas of the P circles, where P is given by

$$(11) \qquad P=N^2+(N-1)^2+4(N-1)+4+4(N-1)^2.$$

Using the radii given by (2), (4), (6), (8), and (10), with the data from (1), we have

$$(12) \qquad K\pi R^2\left[N^2+(N-1)^2(\sqrt{2}-1)^2+4(N-1)(\tfrac{1}{4})^2+4(3-2\sqrt{2})^2 + 4(N-1)^2\left\{\frac{5-3\sqrt{2}}{7}\right\}^2\right]$$

$$(13) \qquad =\frac{\pi S^2}{4N^2}\left[N^2+(N^2-2N+1)(3-2\sqrt{2})+\frac{(N-1)}{4} + 4(17-12\sqrt{2})+4(N^2-2N+1)\frac{(43-30\sqrt{2})}{49}\right].$$

It now becomes apparent that as N approaches infinity the third and fourth terms in the brackets approach zero; that is, Circles "C" and "D" contribute nothing to the limiting area.

The actual limit is seen to be

$$(14) \qquad \pi S^2\left[\frac{1}{4}+\frac{3-2\sqrt{2}}{4}+\frac{(43-30\sqrt{2})}{49}\right]=.3048\pi S^2=.9575S^2.$$

It is interesting to note that if we let the number of "A" circles equal 10^2, the total number of circles, P, given by (11), is

$$(15) \qquad 100+81+36+4+324=545.$$

Territory is but the body of a nation. The people who inhabit its hills and valleys are its soil, its spirit, its life.—*James A. Garfield.*

A COMPLEX QUANTITY SLIDE RULE

G. R. Shuck
University of Washington, Seattle 5, Washington

The electrical engineer, in his various calculations of electrical circuits, has occasion to frequently use complex quantities such as $a+jb$, which indicates a horizontal component a added to a vertical component b at right angles to a. The operator j has a value equal to the $\sqrt{-1}$. Since $j^2=-1$ indicating a rotation of 180°, then j indicates a rotation of 90°.

So the electrical engineer uses this notation to indicate the phase relations between voltages and currents. For example, the voltage of a circuit may be $40+j30$, a horizontal component of 40 and a vertical component of 30. The current of the circuit may be represented by $6+j1.5$. To obtain the product of the voltage and current, these two vectors are multiplied together in accordance with the ordinary rules of algebra, giving 195 $+j240$. This operation requires four multiplications and two additions.

We may also express these voltage and current vectors in polar coordinates, voltage $=50\angle 37.86°$ and the current $=6.18\angle 14.5°$, indicating a voltage vector of 50 at a + angle of 36.86° from the horizontal, and current vector of 6.18 at a + angle of 14.5° from the horizontal. To get the product using this notation, the scalar values are multiplied and the angles added, giving $309\angle 51.36°$.

This latter method of obtaining the product suggests the use of a circular slide rule which combines the two methods.

The circular slide rule is made up of three essential parts.

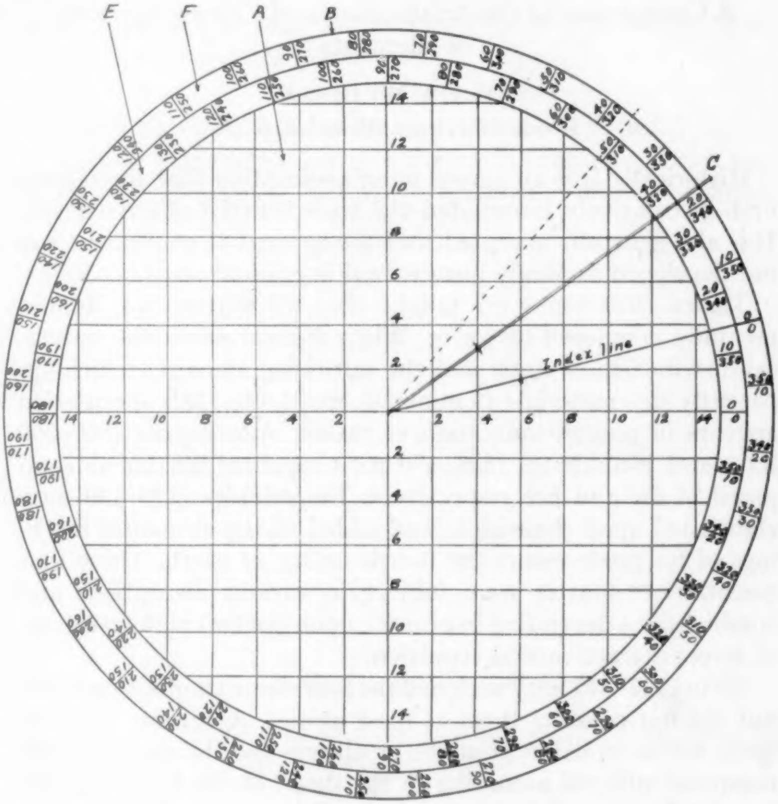
Part A is a circular stationary plate, upon which is drawn a coordinate scale with the 0.0 point at the center of the plate. Around the circumference of this plate is a degree scale E.

Part B is made of a circular transparent plate (cellophane) arranged to rotate about the 0-0 point of plate A. On the circumference of this plate is drawn a degree scale F. 0° of this scale is on an index line scaled off to logarithm of coordinate scale on A, and provided with a slide.

Part C consists of a narrow strip pivoted also at the coordinate scale 0-0 on A. A scale is marked on this strip equal to the logarithm of the coordinate scale of A. A slide is also provided to slide on this strip.

To multiply $40+j30$ by $6+j1.5$ set index line of B on the

coordinate point $6+j1.5$ of A, read the log .791 on index line and set slide on this point. Set slide of strip C on the point $4+j3$ of A, read log .699 on log scale of strip C (1.699 corresponding to $40+j30$), and angle 36.86°+on scale E. Now set strip C on angle 36.86° of F scale. Add log .791 and 1.699 giving 2.49. Set slide on log .49 and opposite this log on strip C read the coordinate point $1.95+j2.4$ on A which corresponds to log .49, giving $195+j240$ corresponding to log 2.49.



The solution of the quotient of two complex quantities requires eleven operations; four multiplications, three additions, two squares, and two divisions. To divide $19.5+j24$ by $4+j3$ by means of the slide rule, set index line of B on point $1.95+j2.4$ and read log .49 on index line (1.49 corresponding to 19.5 $+j24$). Set strip C on the coordinate point $4+j3$ of A, read log .699 on log scale of strip C and 36.86°+ on E scale. Now set

strip C on 36.86°− of F scale and the slide of strip C on the diff. of log 1.49 and log .699, .791, and read the coordinate point $6+j1.5$ on A opposite the log .791 on log scale of C.

The + sign after the angle indicates the anti-clockwise scales and the − sign indicates the clockwise scales.

THE CHINESE FIVE ELEMENT THEORY

A Comparison of the Aristotelian and Chinese Systems of Elements

EUGENE W. BLANK
Woodwild Terrace, Metuchen, N. J.

Historically it is an agreed upon assumption that the Greeks first speculatively formulated the basic concept of an element. It is also generally accepted that the concept of an element was not developed suddenly but evolved in gradual steps.

Thales (640–546 B.C.) taught that all matter was fundamentally composed of water. When one considers the universal distribution of water and the surprising amount in such apparently dry materials as minerals, wood, etc., this speculation appears to possess some basis of reason. Anaximenes (560–500 B.C.) and Herakleitos (536–470 B.C.) regarded matter as composed of air and fire respectively. Empedokles (490–430 B.C.) elaborated upon these ideas and added to the elemental teachings of his predecessors the fourth entity of earth. These four essentials of matter were subject to various disruptions and combinations depending in general, upon the two manifestations of force; attraction and repulsion.

Plato (427–347 B.C.) accepted the four elements of Empedokles but did not consider them as fixed unities. According to Plato space was bounded by triangles or squares and the elements thus composed differed according to the shape of the bounding surfaces and the resulting form of the element. Earth was represented by the cube and was therefore the most stable element as the squares bounding it could not form any other solid. If the bounding surfaces were triangles fire resulted. Air was formed of octahedra.

The significant advance in Plato's thinking over that of his predecessors consisted in the idea that as the bounding surfaces, with the exception of the cube, could evolve into different forms

by suitable rearrangement so there was a possibility of the transmutation of the elements.

Aristotle (384–322 B.C.) augmented the gradually unfolding picture of the element with his speculation that all substances evolve from a primary material known as *hylê*. The form derived from *hylê* by internal growth was called *eidos*. The idea of the transmutation of elements was a direct result of applying logic to this basic concept. Any *eidos* could be broken down into *hylê* and then converted into a different *eidos*, that is to say, the forms of *eidos* were interchangeable. This change can be represented in the following manner:

$$\text{eidos}_{(a)} \leftrightarrow \text{hylê} \leftrightarrow \text{eidos}_{(b)}$$

Aristotle's views were eventually elaborated into the theory of the four material elements, a theory incidentally, which persisted for a good many centuries, with more or less modification,

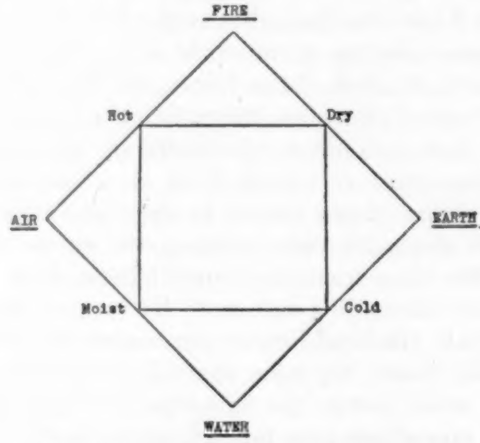


FIG. 1. Aristotle's System of Elements

up to the close of the eighteenth century. Schiller, the German poet, refers to the theory in these lines:

> "Vier Elemente, inniggesellt
> Bilden das Leben, bauen die Welt."

According to Read (1) a similar theory of matter was known in both India (under the name of Brahma) and Egypt as early as 1500 B.C.

Histories of chemistry usually present Aristotle's views on the composition of matter in the form of a diagram similar to that reproduced as Figure 1, (2).

Few chemical histories, however, do more than allude to the fact that the Greeks recognized the existence of a country known as China and that the four-element theory of the Greeks may have reached China by infiltration with Buddhism from India.

Recent studies indicate that China, rather than Egypt is the original home of alchemy. Chinese alchemy probably reached the Arabs and thence Europe, by way of Persia (3). The subject is still in dispute (4).

Five elements were recognized by the Chinese as early as the twelfth century B.C. and were soon correlated with magic quintets of virtues, tastes, colors, tones and seasons.

The five element cosmology conceived by the Chinese evolved mythically and in several historical steps analogous to the slow growth of the Greek theory. Chinese creation in totality, of which the five elements in poetical form comprise an important part, is known to sinologists as the P'an Ku myth.

The Chinese conceive of the world as evolving from a watery chaos by the unification of two forces, *yin* (the principle of material acted upon) and *yang* (the principle of activity) (5). The reaction of these two forces culminated in the creation of a gigantic human creature named P'an Ku. The watery wastes meanwhile coalesced and turned to stone and P'an Ku worked for eighteen thousand years shaping the earth, the sun, the moon and the stars from the stone at hand. P'an Ku grew in stature at an astounding rate until he became identified with the earth itself. His head formed the mountains, his breath was the mist and cloud, his voice the roll of thunder. The rivers formed his veins, forests the hair which covered his skin. The metals and ores which were taken from the earth were his bone and sinew. His sweat became the gentle rain and earthquakes the convulsive tremblings arising from his great exertions. Finally the insects which annoyed him took the form of the countless millions of people who lived and died on the body of this great giant. Then he died but not before five ancients had arisen to take charge of various portions of the earth. It is these ancients that are of greatest interest to us.

The Yellow Ancient became ruler of the earth. The second, known as *The Red Lord* ruled over fire and made his home to the south. The third known as *The Dark Lord* ruled over the waters and had his domain located in the north. The fourth, *The Wood Prince* ruled over wood and lived in the east. The

fifth, *Mother of Metals* lived to the west. The Yellow Ancient was homeless and perforce roamed amidst mankind occupying his time teaching mankind the useful arts. The subsequent reincarnations of this personage are of interest. Today he is known as the Old Man of the River and reputed to possess great knowledge. Statues represent him as an old man carrying a staff and endowed with a prominent forehead denoting great mental stores.

Yin and Yang were associated with the Sun and Moon respectively and the five elements with the planets Mercury (water), Mars (fire), Jupiter (wood), Venus (metal) and Saturn (earth). The ancient Chinese doctrine of Yin-Yang shows interesting parallelisms with the alchemical Sulfur-Mercury theory of the western world (6). Much later the phlogistonists of the eighteenth century identified the two contraries as Phlogiston and Calx.

The Chinese have always associated color with direction and this idea originated with the naming and place of abode of the five ancients. North was white, east yellow, south red and west black. In many parts of the Orient this color custom still is followed in the painting of city gates that face squarely in these directions. It is of interest to note that most early races of mankind have associated direction with color. The Mayas had four semideities (bacabs) who were reputed to support the four quarters of the heavens (7). Their symbol colors were yellow, white, black and red.

As usually presented in histories of China the P'an Ku myth does not show the striking parallelisms with Aristotle's views that can be demonstrated by arranging the Chinese concepts in diagrammatic form similar to that encompassing Aristotle's views. The term parallelism is used advisedly because although it can be proven historically that the Greek system was known to the Chinese, they, in their characteristic fashion, did not adopt it outright but modified and elaborated it to bring it sufficiently into conformity with their own views which had been evolving for centuries before the Greek influence was felt.

The Chinese system of thought can be concisely diagrammed as represented in Figure 2.

After the five ancients had ruled for a period there arose a person known as the *True Prince* or the white *Jade Ruler*. The five ancients submitted to his rule and he was installed in the Jasper Castle of White Jade overlooking the thirty-three

heavens and the world. To this day white jade in China signifies perfection.

From a comparison of Figures 1 and 2 a number of similarities and some anomalies are apparent. The elements are arranged in much the same order in the two diagrams. The Chinese have added a fifth element, wood, but if this were omitted and earth moved to the right to occupy the position of wood the two systems would be practically identical. Mellor makes the observation that the Chinese element wood was never recognized as an element in the west (8). Fire and water have been interchanged in the two systems but that may be a result of the peculiar ideas of the Chinese respecting up and down, directions which bear a purely conventional connotation.

Another conclusion to be drawn from an examination of the two systems is that the unifying hylé or quintessence of Aristotle may well be represented in the Chinese system by the White Jade Ruler. Although this has not previously been pointed out it is quite possible that in the Chinese system the White Jade Ruler was subsequently evolved to supply the need for a coordinating principle among the elements.

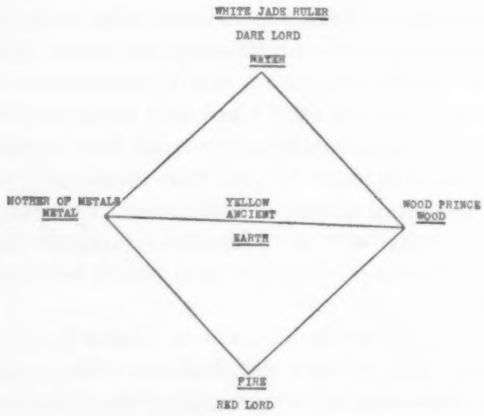


FIG. 2. The Chinese System of Elements

Chinese Buddhism symbolized the five elements by the square (earth), circle (water), triangle (fire), crescent (air) and the gem (aether). Centuries later in Europe the crescent and gem were combined by the alchemists to form the symbol for air and employed thus in their writings.

The Chinese five element theory may seem very distant and

esoteric but to this day in China are found monuments (stupas) built in the general shape of a combination of the symbols for the five elements.

Recent studies of the contributions of the early Chinese to chemistry indicate that we, perhaps, owe a great deal more to their endeavors than has hithertofore been recognized.

Literature Cited

1. Read, "Prelude to Chemistry," p. 9, Macmillan Co., New York (1937).
2. Partington, "A Short History of Chemistry," p. 14, Macmillan and Co., Ltd., London (1939).
3. Davis, "The Chinese Beginnings of Alchemy," Endeavour 2, 154 (1943).
4. Partington, Nature 119, 11 (1927).
5. Nourse, "A Short History of the Chinese," 3rd Ed., p. 23, New Home Library, New York (1943).
6. Read, *loc. cit.*, p. 21.
7. Verrill, "Old Civilizations of the New World," p. 103, New Home Library, New York (1942).
8. Mellor, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry," Vol. 1, p. 22, London (1922).

THE QUIZ SECTION

Julius Sumner Miller
Chapman College, Los Angeles 27, California

1. If a cone, a hemisphere, and a cylinder be erected over the same base circle, and all three have the same altitude, what is the ratio of their contents? (Hugo Brandt, Chicago)
2. Consider a ball tossed vertically upwards. How does doubling the initial velocity effect the time of ascent and the height to which it rises?
3. One looks *toward* the sun to see a new moon; *away* from the sun to see a full moon. (T or F)
4. Name the authors of: (a) ***Philosophiae naturalis principia mathematica***
   (b) ***De revolutionibus orbium caelestium***
   (c) ***The Almagest***
5. If you looked at this type through a thick glass plate, would the type appear nearer or farther than it actually is?
6. In going a distance of 4 miles a man covers the first two miles at 30 mph. How fast must he go over the second two miles to average 60 mph for the trip?
7. The "eye" of a potato is an undeveloped leaf. (T or F)
8. A room contains 100 flies at 12 o'clock noon, and the number doubles each minute. If the room is filled at 1 p.m. when was it $\frac{1}{4}$ full?
9. Every lunar eclipse is visible from at least half the earth. (T or F)

ANSWERS TO THE QUIZ SECTION

1. 1:2:3; 2. doubles the time of ascent, quadruples the height; 3. T; 4. Newton, Copernicus, Ptolemy; 5. Nearer; 6. Impossible; 7. T; 8. at 12:58 p.m.; 9. T.

DEVELOPING AN UNDERSTANDING OF OUR NUMBER SYSTEM THROUGH PLACE VALUE

JOHN A. MORTON
Director of Mathematics, Kern County, Bakersfield, California

A recent article written by H. Van Engen in the May, 1945 issue of this magazine expressing his views on the importance of place value in the second and third grade was also an expression of many in the field of elementary arithmetic. It was felt, however, that the remarks made by Mr. Engen did not extend far enough downward or upward in elementary arithmetic. It is the purpose of this article to explore the possibilities further on this rather important topic of place value.

In the first place the teaching of place value should be taught in the first grade provided counting, reading, and writing numbers are part of that grade's arithmetic curriculum. However, before place value can be taught children must understand thoroughly the numbers from 1 to 9 inclusive. It is not sufficient for a child to be able to count for he must also realize the relationships involved in the digit or unit numbers. Although a child may say 4, 5, and can count the objects, we do not have any assurance that he has a clear concept of fourness or fiveness, merely because he can count in series. Fourness may mean to a child the next number following three, or the last number of counted objects. Children, therefore, must be aware of the composition of four and other numbers to nine inclusive. Four, then, under this concept, means all the preceding number of objects counted as representing four, it follows three and precedes five, that four is composed of two objects and two objects, or three objects and one more. Only and only after each individual number from one to nine inclusive is understood in a variety of situations as counting objects, pictures, and semi-concrete objects will the abstract number be understood and the way made clear for an understanding of the written number ten.

When the number 10 is presented to a class, confusion and misinterpretation is sometimes evident. The children up to the present have recognized 1 as meaning one, now the teacher tells them that 1 followed by a zero is ten, that 1 followed by 1 is eleven, etc. To the child the marks 1 and 1 in his previous experience in counting equals two. How then can children understand ten and other two place numbers without knowledge of the meaning of the first number in relation to the second?

The answer found in this county at least is to teach place value concretly through use of objects that children can manipulate. Sticks, matches, toothpicks, buttons, the abacus, tongue depressors, and other objects were tried without too much success until Breuckner's[1] method of using the first grade pocket or wall chart was discovered.

The primary advantage of the wall chart enabled children to keep the tens and units separated which was not possible when working at their desks with objects as was done before. By drawing two lines with chalk the length of the pocket chart and heading the columns thus made with the words ones (units), tens, and hundreds the children grasped the idea of place value more readily.

The objects one uses to insert in the pockets of the wall chart is conditioned by their thickness, therefore, strips of tag board of different colors were used. The teacher inserts the single slips side by side in one of the pockets in the one's column. Frequent pauses were made for different children to come to the blackboard and write below the suspended chart the number representing the total slips of paper. When ten slips have been inserted they are fastened together and moved into a pocket in the tens column. This bundle then represents one bundle of ten or 1 ten. A child is called upon to write the number of bundle below the chart, which is number one. Since the one's column is blank, children volunteer that to show blankness one should place a zero underneath the column of ones. Ten is now established as meaning 1 ten and 0 ones, eleven as 1 ten and 1 one, twelve as 1 ten and 2 ones, etc., to 20. At this point a new bundle of 10 ones is fastened together and inserted beside the one ten already present. A child then writes below the ten's column the number two and a zero under the one's column making 20 or two tens. The teacher may continue this procedure in subsequent lessons furnishing the new name for each decade the child writes below the chart. This is necessary since the tens, twenties, thirties, and fifties do not start with the name of the number as does forty (four), sixty (six), etc. to 100.

This striving for understanding of our number system is continued into the second grade although the writer has seen children playing with the strips of paper in the first grade and has

---

[1] Breuckner, Leo J., Grossnickle, F. E., Merton, E. L., *Teacher's Guide for Arithmetic We Use*, Los Angeles, The John C. Winston Company, 1943, page 46–47, and Kern County *Tentative Mathematics Manual*, Grades 1 to 8, Kern County Schools, Bakersfield, California.

watched them continue counting into the thousand column.

Where place value has been maintained in the primary grades, through the chart technique, children have very little difficulty in realizing the ones column should be added before the tens column, what and why of carrying, and the placing of the sum in the right position in column addition.

In subtraction, involving borrowing, the chart and strips of paper offer a concrete illustration of how, why, and how much is borrowed. A graphic illustration is used however, to accompany the chart, thus:

35 =	3 tens	5 ones or	2 tens	15 ones	
−18 =	1 ten	8 ones =	1 ten	8 ones	
			1 ten	7 ones or 17.	

By the time the primary multiplication facts are presented to children, place value should be fairly well established. Since multiplication is re-grouping[2] into tens, children can use their past experience with place value in building the multiplication facts. The sign for multiplication should not be presented at this time, instead a longer form carries more meaning such as, two 8's, three 5's, five 3's, etc. Wheat[3] advocates the meaning of multiplication is clearer by grouping the two 8's as follows:

•••• •|•••
•••• •|••• count out 10 of the small dots and draw a ring about them. In the illustration, the answer is 1 ten and 6 left over or 1 ten and 6 ones or 16.

In the longer process of multiplication using two digit numbers the knowledge of place value adds meaning to carrying, indentation, and the value of partial products. In the example,

36
24
—— the partial product of 144 is understood to be a regrouping
144
72
——

of 36 four times or 144. The 72 however is rarely understood to mean 720, unless children are conscious of place value which in this case the 2 of the 24 in the multiplier is thought of as being

[2] Wheat, H. G. *The Psychology and Teaching of Arithmetic,* New York, C. C. Heath and Co., 1937, 59 pages. Page 304–305.
[3] *Ibid.* Wheat, H. G., page 304–305.

two 10's. In the partial product 72 the 2 represents tens and the 7 hundreds.

By using two pocket charts in the intermediate and upper grades the relationship of whole numbers and decimals are readily shown. The moving of strips of paper from the thousandths position to hundredths, then tenths, to a whole number has proven a successful teaching device and a boon to many teachers.

Although place value is not thought of as being part of teaching meaning and understanding in denominate numbers the same technique of adding, subtracting, and multiplying denominate numbers may be used as employed in whole numbers and decimals.

SCHOOL WAR SAVINGS TOP $1,767,000,000 TO DATE!

Breaking all previous records, the War Savings of teachers and students in the past school year have reached $715,000,000 bringing the total of their wartime savings to well over one and three quarter billion dollars.

"I congratulate the boys and girls and their teachers for this magnificent contribution to the fight for victory and a just peace," said President Harry S. Truman to the two District of Columbia students who made the official report for their classroom cohorts across the country.

The official presentation ceremony took place in the President's study at the White House on July 5 just before he left for the Big Three conference in Potsdam.

The official report to the President as Commander-in-Chief was made in the form of a mahogany plaque featuring the Schools-at-War flag in a bronze medallion.

Back of that plaque stand 30,000,000 school children and a million teachers whose continued savings this year have made possible the sponsorship of nearly 20,000 pieces of military equipment for the Armed Forces. The field ambulance has been the most popular single item of equipment, with the schools sponsoring 8,246 during the past year. Greatest dollar investment was in 114 hospital service planes valued at $14,250,000.

The official report of school-sponsored equipment includes: 5,741 jeeps, 2,869 planes, 355 landing craft and 58,461 life rafts. In addition they have financed army mules, machine guns, trucks, bomb trailers, potato-peeling machines, demolition bombs and thousands of ampules of penicillin.

The new campaign for Fall will feature hospital equipment and medical supplies as the most urgently needed materials.

Just as we have succeeded in releasing atomic energy from uranium, we must release the energy from the minds of our youth. In the fertile brains of American boys and girls are the master keys to the future. We must stimulate and encourage youth, if this nation is to have health, prosperity and security. With its natural interest in science, youth is America's greatest natural resource.

DAVID SARNOFF

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1933. *Proposed by Howard D. Grossman, New York City*

Solve:

$$x^2-y=y^2-z=z^2-w=w^2-x=2.$$

Solution by Brother Alfred, Napa, Calif. and the proposer (composite)

The equation

$$x^2-y=2 \text{ may be written } \left(\frac{x}{2}\right)^2=\frac{y/2+1}{2}$$

showing that $x/2$ and $y/2$ are to each other in the relation of the cosine of an angle and the cosine of a double angle.

Let

$$x/2=\cos A \quad \text{and} \quad y/2=\cos 2A.$$

From the other entirely similar equations, we have

$$z/2=\cos 4A, \qquad w/2=\cos 8A, \qquad x/2=\cos 16A.$$

Hence the problem reduces to determining those angles which satisfy the relation:

$$\cos 16A=\cos A$$

and which give distinct values to the cosine. The solutions satisfying these conditions are given by the equations:

$$16A=360n+A \qquad (n=0, 1, \cdots, 7)$$
$$16A=360n-A \qquad (n=1, 2, \cdots, 8).$$

This gives $17A = 2\pi n$ and $15A = 2\pi n$ from which there are seen to be 16 solutions

$$\text{For } A=0, \qquad x=y=z=w=2.$$
$$\text{For } A=120°, \quad x=y=z=w=-1.$$

The remaining solutions are:

$$x, y, z, w = 2\cos\frac{2\pi}{17}, \quad 2\cos\frac{4\pi}{17}, \quad 2\cos\frac{8\pi}{17}, \quad 2\cos\frac{16\pi}{17}$$

in cyclical order (4 solutions)

$$x, y, z, w = 2\cos\frac{6\pi}{17}, \quad 2\cos\frac{12\pi}{17}, \quad 2\cos\frac{10\pi}{17}, \quad 2\cos\frac{14\pi}{17}$$

in cyclical order (4 solutions)

$$x, y, z, w = 2\cos\frac{2\pi}{15}, \quad 2\cos\frac{4\pi}{15}, \quad 2\cos\frac{8\pi}{15}, \quad 2\cos\frac{16\pi}{15}$$

in cyclical order (4 solutions)

$$x, y, z, w = 2\cos\frac{2\pi}{5}, \quad 2\cos\frac{4\pi}{5}, \quad 2\cos\frac{2\pi}{5}, \quad 2\cos\frac{4\pi}{5}$$

in cyclical order (2 solutions)

1934. *Proposed by M. Kirk, West Chester, Pa.*

Find the sum to infinity:

$$\frac{1}{3}+\frac{1}{3}\cdot\frac{3}{6}+\frac{1}{3}\cdot\frac{3}{6}\cdot\frac{5}{9}+\cdots.$$

Editor's note:—This problem appeared as 1892 in the Jan. 1945 issue. Solutions now offered are similar to the earlier solution. They were by Paul H. Renton, West View, Pa.; Howard D. Grossman, New York City; Brother Alfred, Napa, Calif.; W. Kirk, West Chester, Pa.; Roy Wild, Somewhere in France.

1935. *Proposed by J. Frank Arena, Hardin, Illinois*

Solve for x, y, z:

$$x+y+z=6$$
$$x^2+y^2+z^2=14$$
$$xyz=6.$$

Solution by Julius Sumner Miller, New Orleans, La.

$$x+y+z=6 \tag{1}$$
$$x^2+y^2+z^2=14 \tag{2}$$
$$xyz=6 \tag{3}$$

Multiply (1) by x:

$$x^2+xy+xz=6x. \tag{4}$$

Subtract (2) from (4):

$$xy+xz-y^2-z^2=6x-14. \tag{5}$$

Square (1):

$$x^2+y^2+z^2+2xy+2xz+2yz=36. \tag{6}$$

Replacing in (6), $x^2+y^2+z^2$ by its value 14, we obtain

$$xy+xz+yz=11. \tag{7}$$

From (3) use

$$xy=\frac{6}{z}$$

and from (1) use $x=6-y-z$. Put these in (7). We obtain

$$z^3-6z^2+11z-6=0$$

which has the roots 1, 2, 3. Now repeat the process obtaining identical cubic equations in y and in z. Associating the values, we have finally

$$(1, 2, 3);\ (1, 3, 2);\ (2, 1, 3);\ (2, 3, 1);\ (3, 1, 2);\ (3, 2, 1).$$

Solutions were also offered by Clarence R. Perisho; Joseph Lerner, New York; McCook, Nebr.; Brother Alfred, Napa, Calif.; Hazel Wilson, Annapolis, Md.; Edith M. Warne, Columbia, Mo.; Walter R. Warne, Columbia, Mo.; M. Kirk, Media, Pa.; Hugo Brandt, Chicago; M. Scott, Baltimore, Md.; Paul H. Reuton, West View, Pa.; Kenneth G. Stone, Brookings, S.D.; M. Schiffenbauer, New York City and the proposer.

1936. *Proposed by Felix John, Philadelphia, Pa.*

Prove that $17^{2n+2}-288n-289$ is divisible by 82, 944.

Solution by Paul H. Renton, West View, Pa.

$$\begin{aligned}
&17^{2n+2}-288n-289\\
&\quad=(17^2)^{n+1}-288n-289\\
&\quad=289^{n+1}-288n-289\\
&\quad=289(1+288)^n-288n-289\\
&\quad=289\left[1+288n+\frac{(288)^2\cdot n(n-1)}{2!}+\cdots+(288)^n\right]-288n-289\\
&\quad=289+289(288n)+289\left[\frac{(288)^2\cdot n(n-1)}{2!}+\cdots+(288)^n\right]-288n-289\\
&\quad=288n(289-1)+289(288)^2\left[\frac{n(n-1)}{2!}+\cdots+(288)^{n-2}\right]\\
&\quad=(288)^2\left\{n+289\left[\frac{n(n-1)}{2!}+\cdots+(288)^{n-2}\right]\right\}\\
&\quad=82{,}944\left\{n+289\left[\frac{n(n-1)}{2!}+\cdots+(288)^{n-2}\right]\right\}
\end{aligned}$$

which is divisible by 82, 944.

Solutions were also offered by Milton Schiffenbauer, New York City; Brother Alfred, Napa, Calif.; Hugo Brandt, Chicago; Roy Wild, Somewhere in France; M. Kirk, Media, Pa.; Joseph Lerner, New York City and the proposer.

1937. *Proposed by Stella Williams, Ithaca, N.Y.*

Solve the system

$$x^4-5xy^3+4y^4=0$$
$$x-y=1.$$

By inspection, a factor of the first equation is $x-y=0$ which is incompatible with the second equation. After removing it, the first equation reduces to

$$x^3+x^2y+xy^2-4y^3=0.$$

Substituting for x from the second leads to:

$$y^3-6y^2-4y-1=0$$

which may be treated in the standard manner. Set $y=z+2$. Then

$$z^3-16z-25=0.$$

Using the ordinary formulas for this reduced cubic,

$$z=A+B,\quad -\frac{A+B}{2}+\frac{A-B}{2}\sqrt{-3},\quad -\frac{A+B}{2}-\frac{A-B}{2}\sqrt{-3}$$

where

$$A=\sqrt[3]{\frac{25}{2}+\frac{1}{18}\sqrt{1473}}\qquad B=\sqrt[3]{\frac{25}{2}-\frac{1}{18}\sqrt{1473}}$$

Then $y=z+2$, $x=z+3$ are the solutions required. The real root is approximately 7.6765.

Other solutions were offered by Milton Schiffenbauer, New York City; Helen M. Scott, Baltimore, Md.; Hugo Brandt, Chicago; Hazel S. Wilson, Annapolis, Md.

1938. *Proposed by Dorothy C. Hand, Clark's Summit, Pa.*

Find the exact lengths of the bisectors of the angles of the right triangle in which one leg is 1 and the hypotenuse is 3.

Solution by Helen M. Scott, Baltimore, Md.

The geometrical formula for the bisectors is

$$d=\frac{\sqrt{bc[(b+c)^2-a^2]}}{b+c}$$

in which b and c are the sides adjoining the bisected angle.

For CF, $a=2\sqrt{2}$; $b=3$; $c=1$.

$$CF=\frac{\sqrt{3[(3+1)^2-8]}}{4}=\frac{\sqrt{6}}{2}.$$

For BD, $a=1$; $b=3$; $c=2\sqrt{2}$

$$BD=\frac{\sqrt{6\sqrt{2}[(3+2\sqrt{2})^2-1]}}{3+2\sqrt{2}}=4\sqrt{9-6\sqrt{2}}$$

For AE, $a=3$; $b=1$; $c=2\sqrt{2}$

$$AE=\frac{\sqrt{2\sqrt{2}[(1+2\sqrt{2})^2-9]}}{2\sqrt{2}+1}=\frac{4(2\sqrt{2}-1)}{7}.$$

Solutions were also offered by Brother Alfred, Napa, Calif.; Hazel S. Wilson, Annapolis, Md.; Milton Schiffenbauer, New York City; Paul H. Renton, West View, Pa.; Clarence R. Perisho, McCook, Nebr.; Hugo Brandt, Chicago; J. F. Arena, Boone, N.C.; Mollie Murphy, Memphis, Tenn.; M. Kirk, Media, Pa.; Walter R. Warne, Columbia, Mo.; W. R.

Smith, Suttons' Bay, Mich.; Gertrude Hamlet, Calgary, Canada; Mabe. Wilcox, St. Johns, Newfoundland; Emma Everts, Chattanooga, Tenn.; Roy Wild, Somewhere in France; and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1934,5. John Moyse and D. C. H. Stanley, both from Upper Canada College, Toronto.

1935. Newton Garber, Philadelphia, Pa.

1936,8. John Moyse.

PROBLEMS FOR SOLUTION

1951. *Proposed by Clarence R. Perisho, McCook, Neb.*

For what value of n, will $n!$, end in exactly 10 zeros. Also show that $n!$ cannot end in exactly eleven zeros.

1952. *Proposed by Joe Nyberg, Chicago*

Find the volume of an icosahedron whose edge is e.

1953. *Proposed by Alan Wayne, Flushing, L.I., New York City*

Find the diameter of the circle in which a chord of length c subtends an arc of length π.

1954. *Proposed by M. Kirk, West Chester, Pa.*

In a right triangle ABC, show that

$$\cot \frac{A}{2} = (c+b)/a.$$

1955. *Proposed by Howard D. Grossman, New York City*

If successive annual mortgage-interest payments of $5,000, $4,900, $4,800, etc. are immediately re-invested at 5% compound interest, compounded annually, find a formula for computing their total value immediately after the last payment.

1956. *Proposed by J. S. Miller, New Orleans, La.*

A projectile is fired from a height h above a level plane with a velocity of v at an angle θ. Find the range.

BOOKS AND PAMPHLETS RECEIVED

Electronic Equipment and Accessories, by R. C. Walker. Cloth. Pages vii+393. 13.5×22 cm. 1945. The Chemical Publishing Company, Inc., 234 King Street, Brooklyn 31, N. Y. Price $6.00.

Introduction to Industrial Chemistry, by W. T. Frier, *Foundry Control Chemist, Erie General Electric Works, and Instructor in Metallurgy, Erie General Electric Technical Night School;* and Albert C. Holler, *Chief*

Chemist and Metallurgist, United States Metal Products Company, Erie, Pa. Cloth. Pages xiv+368. 13×19.5 cm. 1945. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $3.00.

PLANE AND SPHERICAL TRIGONOMETRY, by Harvey Alexander Simmons, Ph.D., *Associate Professor of Mathematics, Northwestern University.* Second Edition. Cloth. Pages xi+387. 14×21.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.25.

A WAR JOB THOUGHT IMPOSSIBLE, by Wesley W. Stout. Cloth. 51 pages. 13×20.5 cm. 1945. Chrysler Corporation, Detroit, Mich.

A GENERAL ACCOUNT OF THE DEVELOPMENT OF METHODS OF USING ATOMIC ENERGY FOR MILITARY PURPOSES UNDER THE AUSPICES OF THE UNITED STATES GOVERNMENT, by H. D. Smyth, *Chairman of the Department of Physics of Princeton University, Consultant to Manhattan District, U. S. Corps of Engineers.* Paper. Pages vii+182. 14×23 cm. 1945. Superintendent of Documents, Government Printing Office, Washington, D. C. Price 35 cents.

THE EVALUATION OF STUDENT REACTIONS TO TEACHING PROCEDURES, by Roy C. Bryan. Bulletin of the Graduate Division, Western Michigan College, Kalamzaoo, Mich. Pages ix+40. 21×27.5 cm. 1945. Single copies $1.00; 5 to 10 copies 75 cents; 10 or more copies 60 cents.

TRAINING SCHOOL BUS DRIVERS, Prepared by The American Automobile Association and The Trade and Industrial Education Service of the Vocational Division. Paper. Pages x+162. 14×23.5 cm. 1945. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 30 cents.

GENERAL EDUCATION BOARD. Annual Report 1944. Paper. Pages ix +115. 14.5×22 cm. 49 West 49th Street, New York, N. Y.

FROM PEARL HARBOR INTO TOKYO. The Story as Told by War Correspondents on the Air. Paper. 312 pages. 10.5×16.5 cm. 1945. Columbia Broadcasting System, New York, N. Y.

MORE FIREPOWER FOR HEALTH EDUCATION, by Arthur H. Steinhaus, Chief, Division Physical Education and Health Activities. Bulletin 1945, No. 2. 49 pages. 14.5×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

SCIENCE FOR LIFE OR DEATH, by Brigadier General David Sarnoff, *President, Radio Corporation of America.* Reprinted from the New York Times, Aug. 10, 1945. 16 pages. 15.5×21.5 cm.

USE OF TRAINING AIDS IN THE ARMED SERVICES. A Report of the Committee on Military Aids and Instructional Materials. Bulletin 1945, No. 9. Pages x+34. 15×23 cm. Superintendent of Documents, Washington, D. C. Price 10 cents.

A NEW BIRTH OF FREEDOM. A Musical Pageant for Junior and Senior High Schools. 18 pages. 20.5×26.5 cm. Copies are obtainable on request to the Educational Section, War Finance Division, U. S. Treasury Department, Washington 25, D. C.

He serves all who dares to be true.—*R. W. Emerson.*

BOOK REVIEWS

TELEVISION PROGRAMMING AND PRODUCTION, by Richard Hubbell, *Production Manager and Television Consultant of Crosley Corporation, Broadcasting Division.* Cloth. Pages xii+207. 15×23 cm. 1945. Murray Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $3.00.

This is a textbook covering the art and science of television program production. The author is a man who has had unusual experience in radio, television, magazine, and advertising work. The expansion of television is another of the great projects which the war delayed. But the intensive war research in the field of electronics will undoubtedly contribute much to television equipment and progress.

The author separates the discussion into four main divisions: The Nature of Television, The Camera, Video Technique and Theory, and The Audio. A part of the discussion is truly historical, telling what has been done, what things have been tried out, the types of cameras used, camera techniques, editing, lighting effects, the use of sound and music. But throughout the book there is also much speculation, suggestion and theory. In groups are many unusual photographs illustrating the use of equipment; scenes showing news programs, commercials, drama, ball games, grand opera; and a typical studio scene. The book contains much that will be of interest to the general reader but it was written especially for those who plan to take an active part in any phase of post-war television as actor, writer, director, advertiser, or technician.

G. W. W.

ELEMENTS OF PHYSICS, by Robert W. Fuller, Raymond B. Brownlee, and D. Lee Baker. Cloth. Pages x+831+13. 13×19.5 cm. 1944. Allyn and Bacon, 2231 South Park Way, Chicago, 16, Ill.

This new book is really not a new one but a revision of an earlier edition (See *First Principles of Physics* which appeared in 1932 and *Elementary Principles of Physics* 1925 by the same authors.) Much of the text has been completely rewritten; some of it appears exactly the same but often with an additional sentence or phrase. (See topics 35 and 36 in the new book, page 42, and compare with topics 44 and 45, page 36 in the 1932 edition.) The entire order of presentation remains practically the same. Recent discoveries, new applications of old principles, and developments in air transportation, radio communication and radar are important new features. Improvement is very noticeable in the illustrations used, both in quality and number. Many of the drawings in the new book are white on a black background, thus giving greater prominence. One of the interesting and instructive features eliminated in the new edition is the numerous full page photographs of great physicists with the short sketch of the contributions of each. This is a sacrifice of an important feature that will be missed by many teachers. The new text continues the use of short chapters followed by good questions, summaries, and excellent problem lists. The language is exceptionally clear; the problems are simple but cover the text well; the lists of questions are definitely fitted to the topics under discussion. This text contains practically all the important aids that a textbook can contribute. It should be considered by all school executives and teachers when new texts are adopted.

G. W. W.

THE NEW APPLIED MATHEMATICS, by Sidney J. Lasley, *Southeast High School, Kansas City, Missouri* and Myrtle F. Mudd, *Northeast Junior*

High School, Kansas City, Missouri. Cloth. Pages xii+431. 15×23 cm. 1945. Prentice-Hall, Inc., New York, N. Y. Price $2.00.

The New Applied Mathematics is a revision of an earlier edition by these authors. Their objective in preparing this text was to provide the material in mathematics necessary for equipping high school boys and girls for every day peacetime needs.

The content includes the fundamental operations with integers, common fractions, and decimals, percentage, denominate numbers, ratio and proportion, direct and indirect measurement, applications in shop work and in business transactions, consumer problems, insurance, taxes, inductive geometry, the formula, equation, and signed numbers. The text contains an abundance of well chosen problems under the various topics. The explanations are brief and clear-cut. Numerous appropriate illustrations and drawings add to the usefulness of the book. The text is adaptable to a course in general mathematics at the ninth grade level or for a course in applied mathematics for older students.

George E. Hawkins

Mathematics of Finance, by Theodore E. Raiford, *Department of Mathematics, University of Michigan, Ann Arbor, Michigan.* Cloth. Pages viii+ +176. 15×22.5 cm. 1945. Ginn and Company, New York. Price $2.50.

The author states that he has aimed at two contributions in presenting this new text on the mathematics of finance. He has used a somewhat different approach to the subject of annuities by presenting the general formulas first with the simpler formulas obtained readily as special cases and by using the double superscript notation with the symbols. He gives a detailed discussion and illustration of the treatment of loans by the direct reduction plan as a recent method in building-and-loan-association practice.

The text includes the topics usually presented in this field. The author takes the point of view that an understanding of the derivation and meaning of the formulas is essential to using them intelligently. The explanations and developments are presented clearly and concisely. These are followed by illustrative examples completely solved. The text contains an abundance of interesting, practical problems for practice.

The text is available with or without tables. The tables for use on interest and annuities give eight decimal places. Logarithms are given to seven decimal places. These tables occupy 305 pages.

George E. Hawkins

Plane and Spherical Trigonometry, by F. Eugene Seymour and Paul James Smith. Cloth. Pages 5+280. 14×21.5 cm. The Macmillan Company, 1945. Price $1.80.

This text was written for high school students, and its authors have attempted to present a course in trigonometry that will be understood and appreciated by such students. This was accomplished by brief clear explanations, a large number of well selected exercises especially in the earlier chapters, and a sequence of topics which makes progress easy. The number of identities seems small but otherwise no omission of material usually contained in trigonometry texts was noted. The text begins with a study of the acute angle. This is followed by the solution of the right triangle including approximate computation and logarithms. Then comes the trigonometry of the general angle, variation and graphs, circular measure, identities and equations, solution of oblique triangles, spherical triangles

with applications, inverse functions, complex numbers, polar coordinates, and the slide rule. Four place tables are included in the text.

A number of significant features of this text are worthy of mention: the complete treatment of logarithms early in the text, the selection of topics in the review of solid geometry in connection with the work on spherical triangles, the work on circular measure and graphs, and the review questions and tests at the close of the various chapters. Provision is made for students of different levels of ability by providing sets of exercises for the average as well as the above average student. The appendix offers supplementary material for the students who wish to do more than a minimum amount of work. This text contains adequate material for a course in high school trigonometry. Students should appreciate the high standard of logic and the clearness and directness of the proofs and discussions.

Hill Warren
Lyons Twp. Junior College,
LaGrange, Ill.

DRUG LABELS MUST SAY WHAT THEY MEAN

Drug labels, from now on, are going to have a very specific meaning. On October 10 new regulations go into effect. If a medicine is safe and effective in the hands of an ordinary citizen, full directions for taking, including a description of what it is good for, will appear on the package. And if it is not safe for self-medication, or if it cannot be satisfactorily used except under the supervision of a physician, it will carry the Rx legend and no extra trimmings. Customers will know that if they are able to purchase a drug over the counter, it is safe when used according to directions.

The Food & Drug Administration has said that Congress, knowing that people always have and would continue to medicate themselves, intends not to outlaw self-medication but to make it safe. Furthermore, directions on safe medicines must be worded so that they are understandable to anyone reasonably familiar with the English language. The Food & Drug Administration will not tolerate an attempt to obscure information behind a screen of technological verbiage.

LONG DISTANCE TELEPHONE CALLS WITHOUT ASSISTANCE FROM OPERATORS

All long distance telephone operators will some day be dialing calls, directly and unassisted, straight through to the called telephone even though it be at the other side of the continent. This method, now in operation to a certain extent, is the announced objective of the American Telephone and Telegraph Company, according to a recent statement made by its president, Walter S. Gifford.

The ultimate aim, Mr. Gifford states, goes further, and will be reached when telephone subscribers can dial "anyone anywhere in the United States or perhaps anywhere in the world just as simply and promptly as you can dial the telephone of a neighbor in your own home town." This long-range goal, he says, is "undoubtedly many years away from practical use."

The first plan is already in use. About 5% of the daily 2,700,000 toll board calls are now being handled by the operator toll dialing method. Under this method the customer dials the outward toll operator, who in turn completes the call to the distant telephone through toll dial equipment, usually without the assistance of another operator.

RADAR, GAS TURBINES, JET PROPULSION AND HELICOPTER TO BE MOST EFFECTIVE IN THE IMPROVEMENT OF AVIATION IN NEAR FUTURE

Radar, gas turbines, so-called jet propulsion, and the helicopter will probably be most effective in the improvement of aviation in the near future, Dr. C. C. Furnas, director of research for Curtiss-Wright's airplane division, told a meeting of the Junior Chemical Engineers.

"The coming era of air travel is almost certainly destined to make major changes in the pattern of American living, and, in the not distant future, in the way of life all over the world," he prophesied.

"One of the fair-haired boys of this war has been radar, which is an abbreviation for 'radio directioning and ranging'," he stated. "Many of its applications and methods of operation are still secret, but in general it may be said that radar uses short radio waves as a substitute for light rays. This makes it possible, with proper instrumentation, to see and to make measurements no matter what may be the conditions of weather or darkness."

Dr. Furnas predicted that radar is going to become the basis for automatically keeping a plane a safe distance above obstacles, for exact navigation at all times, for collision prevention and for blind approach and blind landing systems which will be used in bad weather.

"The principal enemy of aircraft schedules is weather," Dr. Furnas stated, "Mark Twain notwithstanding, you can't do much about the weather. But soon it will be possible to complete scheduled commercial flights no matter what the atmospheric conditions may be."

He pointed out that radar, plus the use of exhaust heat to prevent the formation of ice on the wings and fuselage, will eventually make it possible to maintain a reliability of schedule at least as good as that of the railroads, with almost equal safety.

"If the aircraft manufacturers seriously take hold of the developments which the long-haired physicists have made during the last few years, we can expect to see a real revolution in air travel to begin within the next few years," Dr. Furnas predicted.

The gas turbine may render the conventional reciprocating engine obsolete for aircraft use in sizes above 1,000 horsepower. Recent advances in metallurgy and in certain features of mechanical engineering have now brought this device well into the forefront of the hopeful developments for the future. It will not only be lighter and probably more efficient but will be very much smoother in operation than the engines now in use. This will be an important factor contributing to passenger comfort.

If the public demands planes traveling from coast to coast in five or six hours, we may expect jet-propelled aircraft cruising through the air at high altitudes at a speed between 500 and 600 miles an hour, with not more than one or two stops.

While the helicopter is still a long way from perfection, difficult to fly and not particularly reliable, Dr. Furnas predicts that when some of its problems are solved the helicopter can replace surf boats of the Coast Guard. It can also be used in crop-dusting for the control of pests, for carrying men and equipment to and from forest fires, for use on cattle ranches and in oil fields. Gradually it will evolve as a means of moderate-distance transport for commercial and private use.

Speaking of the private plane, he declared that though small private aircraft will eventually play an important role in all our lives they are not going to have the extensive use or be as important as automobiles. In cost, safety, and convenience small aircraft cannot be in the same category with the automobile.

Small aircraft, Dr. Furnas declared, "will never be able to compete with the third-hand broken-down flivver. They are inherently more expensive than automobiles and they must be kept in top condition or they are definitely unsafe. You can lose a fender or even blow a tire on a car with relative impunity but if you lose a wing or a helicopter rotor blade in the air you only do it once."

SYNTHETIC BLOOD SUBSTITUTE USED BY GERMANS

The Germans used very little blood plasma for treatment of shock in their war wounded. Apparently they never got around to setting up donor centers such as the American Red Cross organized early in the war.

Instead of plasma, the Germans used a synthetic chemical called Periston. American scientists turned thumbs down on it when they studied it. It is a polymer, polyvinyl pyrrolidone, made in the course of developing new plastics. This and related polymers in some ways physically resemble albumin which is probably what led to development of one of them as a blood substitute.

Periston is one of the war developments of the German chemical industry reported by the industrial intelligence staff of the Chemical Warfare Service. Some of it, however, had been obtained from Germany at least two years ago and studied by scientists on the blood substitutes committee of the National Research Council. Although the Germans are reported to have used over 300,000 units of Periston for military personnel, apparently without harmful effects, the blood substitutes committee was of the opinion that it was probably more harmful than materials American medical scientists would accept for a blood substitute. They also found that it was not sufficiently effective to be recommended for use by American physicians and surgeons.

Penicillin was another aid to American wounded which the Germans apparently did not have. They relied mainly on the sulfa drugs for fighting infection in wounds. One of these, Marfanil, was used so widely that apparently they failed to develop a satisfactory production method for penicillin.

RADIO-CONTROLLED MODEL AIRPLANE FOR GUNNERY PRACTICE

A radio-controlled oversized model airplane, carrying no pilot or crew, is used by the Army as a target for antiaircraft gunnery practice here, it is now revealed. The 12-foot wingspan plane, powered with an eight horsepower engine, cuts capers in the sky by radio control which finally stops the engine, opens a parachute and lowers the target safely to the earth.

When wanted for use, the small plane, with its engine wide open, is catapulted like a stone from a slingshot into the air, to be maneuvered by the radio apparatus into steep climbs and deep banks, travelling at about 125 miles an hour. When the gunnery practice is over, a switch is thrown on the remote control apparatus, causing a hatch on the topside of the target plane to open, releasing a parachute by means of which the plane slowly descends.

The radio control is by ultra-high frequency carrier which is generated and modulated by five different audio frequencies. Of these five frequencies four are selected by the stick on the control box on the ground and are used to effect guiding of the plane. The fifth holds the parachute in place for the eventual landing.

FELT HATS MADE OF FUR

In the making of felt hats, glue bonded coated abrasives are an important tool. A felt hat is nothing but loose fur such as rabbit, beaver, or cony fur which is shrunk or fitted together, not woven. A hat in the rough is covered with projecting hairs. It is to remove these hairs and achieve the final lovely finish that coated abrasives are used. Sanding a hat is known in the trade as "pouncing."